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Critical success factors for the large-scale introduction of grid-connected photovoltaic systems

A survey focusing on the non-technical aspects

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Acknowledgement/Preface

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Abstract

This study analyses the differences in Significance and Status of 15 factors that might be of decisive influence in achieving a large-scale market introduction of grid-connected PV systems. As a research method the opinion of PV experts and persons involved in the implementation of PV has been surveyed. Therefore, a questionnaire was sent to about 300 persons all over the world that can be divided in 3 regions America, Europe and Asia. The returned questionnaires have been statistical analysed. The used analytical methods can be divided in a comparing method (Mann-Whitney test) and ranking methods (Friedman test and the Medal-Classification test).

One of the main conclusion is that the ranking of the main critical success factors on Significance shows no large differences between the American and European respondents. The answers from the American and European respondents show that the technical and financial factors are the most Significant; RD&D, technical reliability, financing and cost reduction. The Asian ranking do differ from the American and European ranking. The answers from the Asian respondents show that the international factors; global developments and internationalisation together with specialist knowledge and image are the most Significant success factors.

Another main conclusion is that the three regions differ in the ranking of the actual Status of the factors. A comparison of the American ranking between the Asian ranking show the largest differences, whereas Europe is taking an intermediary position. An interesting observation is that the Status of factors like internationalisation, global developments and the technical/commercial network is regarded more positive in America, whereas Asia and Europe are more positive about the factors RD&D, image and financing.

More specific conclusions show that there is a significant difference in answers between the American and European respondents about the Significance of the factor cost reduction. There is also a significant difference between the answers from the Asian respondents versus the American and European answers about the factor technical reliability.

It also occurs that there is a significant difference about the Status of the factor financing between the American and European respondents versus the Asian respondents. In addition all the respondents have their own idea about the Status of RD&D in their region. Also the Status of the factor technical/commercial network is significant different between Asia and America.

CONTENTS

SUMMARY

Whether an innovation turns out to be successful or not depends on many influences of, for example, scientific, technical and socio-economic nature. Most technology assessments, however, focus solely on the reduction of the production cost, which is ultimately to be reached. Although it is evident that more cost-effective innovative technologies are more likely to succeed, the cost is not the only critical success factor. Other critical factors may be of a comparable or even higher importance.

This also applies to innovations in the field of renewable energy. The aim of this report is to make an inventory and an evaluation of the importance and actual status of critical factors that can be of decisive influence in achieving a large-scale market introduction of grid-connected photovoltaic (PV) systems. In addition, the importance and status of these factors in three different regions of the world - America, Europe and Asia - is analysed[1]. The main purpose of the study is to obtain answers on the following questions:

- Are the different success factors of equal importance in the three different regions?
- What priority can be given or ranking can be made for each region, when comparing the significance of the various success factors?
- Is the actual status of the different success factors of equal importance in the three regions?
- What priority can be given or ranking can be made for each region, when comparing the status of the various success factors?

The present study was carried out in three phases:

1. Identifying and listing of critical factors.
2. Preparing and carrying out the survey.
3. Analysis of the returned questionnaires.

In the first stage of the project, critical success factors that might influence the development process of grid-connected PV systems have been identified based on literature, our own insights and interviews with PV experts. In a first step five main categories of factors have been distinguished, of which four are related to a certain group of actors with specific interest in PV. These five categories are:

- Factors linked to actors involved in the production of systems and system components.
- Factors linked to actors involved in research and development.
- Factors linked to actors on the PV market.
- Factors linked to other actors.
- Factors linked to more general issues.

These categories have been subdivided in more specific actors and issues. By considering the particular interests of these actors and the impact of the specific issues, a list of important aspects could be identified. At a somewhat higher level of abstraction, the most important factors have been deducted in order to define a list of factors that are considered as the critical success factors. Section 3 describes the process of determining these critical success factors.

[1] In this study the American region consists of the United States of America and Canada.
The European region consists of the EU15 completed with Norway and Switzerland. The former central planned East European economies and Russia.
The Asian region consists of the countries Japan, South Korea and Australia.

The main critical success factors are:

- financing,
- cost,
- spatial planning, permits and licences,
- activities in other sectors influencing market introduction,
- environmental merit,
- technical reliability,
- product diversity,
- standardisation,
- specialist knowledge of PV systems and installation,
- image of PV,
- RD&D,
- technical/commercial network,
- internationalisation,
- global developments in other PV sectors.

These factors are used in the second phase to prepare a questionnaire. In the questionnaire the factors have been translated a number of open and closed questions. In the questionnaire PV experts are asked to give their opinion on the Significance of each success factor and the actual Status of this factor in their working area. After a try-out by a group of ECN researchers, the questionnaire was sent to more than 450 PV experts world-wide, including 190 experts with the Dutch nationality. As the Dutch situation will be analysed in a separate report, this report will focus solely on the non-Dutch response, which amounted to 37% of the 262 international sent questionnaires.

Significance or significance
At many places words are written with a capital although these words are not at the beginning of a sentence. This is done to distinguish the Significance of a factor from the significance of a SPSS test result. In consequence also the Status of a factor is written with a capital. Besides Status a factor the Pace of cost reduction, the Current situation of spatial planning & regulation & licensing, the number of initiatives and the Attention for image are written with a capital.

The information in the returned questionnaires has been statistically analysed by means of the SPSS program. Different statistical tests and analysis have been performed in order to answer the four main research questions on the regional differences and the ranking of the Significance and Status of the different success factors. Also the open questions have been analysed in order to get more information on the critical success factors.

The main results on the regional differences in and the ranking of the Significance of the critical success factors are given in Table 1.1.

Ranking of the factors

Table 1.1 *Ranking of the factors according to Significance*

Rank	America	Europe	Asia
1	Financing	Cost reduction	Specialist knowledge
2	Cost reduction	Technical reliability	Global developments
3	RD&D	Financing	Image
4	Technical reliability	RD&D	Internationalisation
5	Image	Specialist knowledge	Financing
6	Specialist knowledge	Image	Spatial planning etc.
7	Standardisation	Environmental merits	Environmental merits
8	Internationalisation	Standardisation	Standardisation
9	Other elements	PV network	PV network
10	Environmental merits	Global developments	RD&D
11	PV network	Product diversity	Technical reliability
12	Global developments	Internationalisation	Cost reduction
13	Product diversity	Spatial planning etc.	Product diversity
14	Spatial planning etc.	Other elements	Other elements

Some interesting observations can be taken from Table1.1:

- Financing and cost reduction are according to the respondents important factors in Europe and America. In Asia other factors are regarded as more important. The more detailed questions show that the 'sale of green power', 'subsidies' and 'tax measures' are regarded as the most important financing methods.
- Also RD&D and the technical reliability are Significant success factors according to American and European respondents. The Asian respondents regard this factor as less important.
- The opposite is true for global developments and internationalisation. The respondents from America and Europe regard these factors as a little less important, whereas in Asia these factors are seen as very important.
- The respondents from all the regions regard the PV network, standardisation, image and environmental merits as more or less important.
- Specialist knowledge is more or less important by the respondents in America and Europe. In Asia this is the most Significant factor.
- Interesting enough the American and European respondents consider spatial planning as the least Significant factor, whereas the Asia respondents find this factor rather important.
- Product diversity is not seen as an essential success factor in one of the regions.

The main conclusion is that the ranking of the main critical success factors on Significance shows no large differences between the American and European respondents. The answers from the American and European respondents show the same characteristics and large-scale market introduction of grid-connected PV may be influenced by the same success factors in order to achieve a successful introduction.

A ranking of the actual Status of the factors in Table 7.2 shows a different picture.

Table 1.2 *Ranking of the factors according to Status*

Rank	America	Europe	Asia
1	Technical reliability	Technical reliability	Environmental merits
2	Environmental merits	Environmental merits	Technical reliability
3	Internationalisation	RD&D	RD&D
4	PV network	Image	Image
5	Global developments	Internationalisation	Financing
6	Standardisation	Product diversity	Standardisation
7	RD&D	Other elements	Product diversity
8	Spatial planning etc.	Financing	Internationalisation
9	Product diversity	PV network	Spatial planning etc.
10	Other elements	Global developments	Cost reduction
11	Cost reduction	Standardisation	Global developments
12	Image	Cost reduction	Other elements
13	Financing	Spatial planning etc.	PV network
14	Specialist knowledge	Specialist knowledge	Specialist knowledge

Some interesting observations can be taken from Table 1.2:

- All respondents are convinced that the technical reliability and the environmental merits of PV systems are well developed.
- The Status of RD&D, image and financing are regarded rather good by the European and Asian respondents. The American respondents see the Status of these factors as rather poor developed.
- Standardisation and product diversity are regarded more or less well developed by all the respondents.
- The Status of the factors internationalisation, global developments and the PV network are regarded as well developed in America, a little less in Europe and less developed in Asia.
- Cost reduction is rather poor developed in all regions.
- All the respondents regard the Status of specialist knowledge as poor developed in their region.

The main conclusion is that the three regions differ in the ranking of the actual Status of the factors. A comparison of the rankings between America and Asia show the largest differences, whereas Europe is taking an intermediary position. An interesting observation is that the Status of factors like Internationalisation, Global developments and the PV network is regarded more positive in America, whereas Asia and Europe are more positive about the factors RD&D, Image and Financing.

The results of this study can be used in many ways for instance in policy making and strategy formulating per region in order to reach large-scale market introduction of grid-connected PV. Although a lot information is already available for these fields the results of this study might reveal new insights. However, it goes beyond the scope of this study to advice decision-makers directly. By looking into the Significance of a specific success factor on the one hand and the actual Status of the same factor on the other hand, a decision-maker may come to his or her own conclusions. The conclusion might be that the factor needs to be addressed in policy making or a strategy formulation or that it can be neglected. Although it is very tempting to start working on, this explicitly goes beyond the scope of this study and needs to be done for a certain region and from a certain perspective like that of policy making or commercial strategy formulation. Therefore, recommendations on policy or strategy are not in this report.

1. INTRODUCTION

Whether an innovation turns out to be successful or not depends on a multitude of influences of scientific, technical and socio-economic nature. Many technology assessments, however, focus solely on the cost price, which is ultimately to be reached. Although it is evident that more cost-effective innovative technologies are more likely to succeed, the cost is not the only critical success factor. Other critical factors may be of a comparable or even higher importance. This also applies to innovations in the field of renewable energy [Varadi, P.F. 1998]. The purpose of this study is to make an inventory and an evaluation of the Significance and actual Status of the critical factors that can be of decisive influence in achieving a large-scale market introduction of grid-connected photovoltaic (PV) systems. In addition, the Significance and Status of these factors in three different regions of the world - America, Europe and Asia[2] - is analysed.

Significance or significance
At many places words are written with a capital although these words are not at the beginning of a sentence. This is done to distinguish the Significance of a factor from the significance of a SPSS test result. In consequence also the Status of a factor is written with a capital. Besides Status a factor the Pace of cost reduction, the Current situation of spatial planning & regulation & licensing, the number of initiatives and the Attention for image are written with a capital.

This study tries to make the perception that the ranking in Significance and actual Status of different critical success factors differ from region to region more explicit and inter-subjective. Actually the opinion of many PV experts acting in the different regions form the basis for the results.

Policy makers or commercial parties can use the results of this study in formulating a strategy for reaching a large-scale market introduction of grid-connected PV systems or, respectively, in order to reach a large market share.

[2] In this study the American region consists of the United States of America and Canada.
The European region consists of the EU15 completed with Norway and Switzerland. The former central planned East European economies and Russia.
The Asian region consists of the countries Japan, South Korea and Australia.

2. METHODOLOGY

The present study was carried out in three phases:

1. Identifying and listing of critical factors.
2. Preparing and carrying out the survey.
3. Analysis of the returned questionnaires.

In the first phase of the project, critical success factors that might influence the development process of grid-connected PV systems have been identified based on literature, our own insights and interviews with PV experts. Annex A to this report offers a list of the experts interviewed at ECN. The result of this inventory has been communicated to experts participating in the Joint Solar Panel[3]. Comments from the Joint Solar Panel were incorporated in the inventory, resulting in a list of factors, which might influence the development process of grid-connected PV systems (see Section 3 of this report).

In the second phase a questionnaire was formulated based on information from the first stage of the project. The questionnaire focuses on the Significance as well as the Status of the various non-technical aspects of PV in the region where the respondent works. The questionnaire is attached as Annex B.

The questionnaire was sent to 450 PV experts world-wide. The experts were identified and selected from the participants in the Second World Conference on Photovoltaic Solar Energy Conversion held on 6-10 July 1998 in Vienna, Austria, and from the list of participants in the national research programme NOZ-PV[4] in the Netherlands. The questionnaire could be returned by e-mail, fax or ordinary mail. After three weeks a reminder was sent to all the experts who at that time had not yet responded. Annex C contains a list of the respondents who have returned their questionnaire.

The third phase of the project consisted of the statistical analysis of the returned questionnaires, in order to obtain answers to the following questions:

- Is the actual Significance of the different success factors of equal importance in the three regions?
- What priority can be given or ranking can be made for each region, when comparing the Significance of the various success factors?
- Is the actual Status of the different success factors of equal importance in the three regions?
- What priority can be given or ranking can be made for each region, when comparing the Status of the various success factors?

[3] A body consisting of interested Dutch parties with industrial as well as governmental and scientific backgrounds.
[4] Nationaal OnderZoekprogramma – PhotoVoltaische energie.

3. DETERMINATION OF THE FACTORS

The lowest cost price feasible in the near or far future is generally regarded as the most important factor for success of PV technology. Therefore, technology assessments usually focus on potential cost reductions and efficiency improvements in components to be achieved by the application of different technologies and materials. In addition, economies of scale and learning effects in the production of cells and modules play an important role.

In addition to these more or less well-known scientific-technical factors, other factors need to be assessed as well. Examples are the market demand and the political and legal factors that may differ per region. These factors need to be assessed in order to evaluate the innovation process of PV technology.

This section provides an overview of the essential actors and several more general factors, based on literature, our own perspectives and interviews with experts at ECN (see annex A). The literature most frequently consulted in this study includes Callon, M. et al. (1992), Dijkstra, B.R. (1992), Kampen, B.J.M. et al. (1999), Kruijsen, J. (1999), Langman, M. et al. (1999), Oliver, M. et al. (1999), Toggweiler, P. (1999) and Varadi, P.F. (1998).

Five main categories of factors have been distinguished, of which four are related to a certain group of actors with a specific interest in PV. The five categories are:
- Factors linked to actors involved in the production of systems and system components.
- Factors linked to actors involved in research and development.
- Factors linked to actors on the PV market.
- Factors linked to other actors.
- Factors linked to more general issues.

These five categories have been translated into a list of 23 specific issues. This list has been validated and completed by experts from the Joint Solar Panel. With this list, a new overview has been made of essential factors for grid-connected PV systems. These factors are translated into questions used in the questionnaire (see annex B).

3.1 Actors' interests & other factors

The assumption made in preparing the list with the most essential factors is that most of them, in one way or another, are reducible to the interests of the actors involved. Furthermore, there are a number of factors of a more general nature that do not deal with interests of specific actors involved. Thus, the following main groups can be distinguished:

1. Actors involved in the production of systems and system components:
   - Manufacturers of basic materials and components.
   - Original Equipment Manufacturers.

2. Actors involved in Research and Development:
   - Research institutes.
   - Private sector companies.
   - National governments.
   - International research programmes.

3. Actors on the PV market:
   - Investors/owners.
   - Users.
   - Governmental parties at different levels.
   - Energy companies.

4. Other actors involved:
   - Installation companies.
   - Financial institutions.
   - Architects, building contractors.
   - Do-it-yourself companies.
   - 'Ideological' organisations such as Greenpeace or the World Wildlife Fund.

5. General factors:
   - The PV network.
   - The global perspective of PV.
   - Relation with other renewables.
   - Relation with autonomous PV systems.

The considerations and interests of the different actors and the influence of the general factors may differ strongly. The following four sections summarise the possible considerations and interests of all actors. Then, in Section 3.1.5, attention is given to the more general factors.

3.1.1 Actors involved in the production of systems and system components

Manufacturers of basic materials and components

The manufacturers of basic materials and components such as cells, electronics and other Balance-Of-System components may be driven primarily by several considerations including increase of their turnover, maximisation of their profit and stabilisation of their operational business. Grid-connected PV systems are increasingly becoming a growing market. Long-term perspectives concerning the expected market volume may cause manufacturers to invest in the development and production of new products, although the yield from business activities is currently rather modest. Especially the expectations for the medium and long term may strongly influence the growth process of grid-connected PV technology.

Until the present time most manufacturers have operated from relatively protected home markets, where they have co-operated with other national manufacturers. The government incited by concrete policy targets concerning the implementation of renewable energy, has often substantially supported this home market.

The required increase in scale of production forces these companies to aim increasingly at expansion on the world market. The experience gained in the home market enables them to cope with the competition in the world market.

Finally, the establishment of a flexible production system may be important. Processes enabling the production of a variety of products for different applications with a high degree of standardisation, a high reliability, low investment costs, a high throughput, etc. may be important especially for the production stage.

Original Equipment Manufacturers

The large potential and the market perspective in the intermediate and longer term may also attract manufacturers who build systems from basic components. In addition, flexibility in production may be of importance. These companies, usually producing for the local market, adapt their production capacity relatively easily to the market demand. For these companies the home

market is the most important market, although they may have the potential to start business activities in other countries as well. In addition, a high degree of standardisation, high reliability, and security of supply of basic materials and components may be important for these companies.

3.1.2 Actors involved in research and development

Research institutes

Research institutes may play a decisive role in accelerating the incubation stage. Research institutes are driven by the urge to be leaders in development. Because the competition is strong between institutes, strategic alliances are sometimes made. Developments in the area of PV increasingly lead to new commissions in fundamental and applied scientific research. The main concern of research institutes is achieving technological breakthroughs in the field of cells, modules, inverters and systems (cost prices and efficiencies).

Private sector companies

Private sector companies conduct applied research mainly for use in practical short-term market opportunities. Most of these companies are already developing PV technology or co-operating with research institutes. The developments involve combined applications, such as solar roofs for the combined production of electricity and heat, PV systems serving as roof covering or façades producing electricity and serving as sunblind at the same time. An entrepreneurial spirit and the willingness to take (financial) risks are needed to undertake R&D activities in this sector.

National government

National governments have various reasons to stimulate research and development in the PV field. Reasons could be environmental and climate policy targets, economic purposes or other issues. Expertise that has been built up at the start of a supposed large-scale introduction of PV systems may lead to competitive advantages for private sector companies.

Another reason may be that a large-scale application of solar energy will reduce the dependency on oil exporting countries, which, in the future, will lead to more political and economic independence. For a government, it is, however, less important if these targets will be realised by PV or by other renewable energy options such as wind energy or biomass. A government mainly tries to stimulate the use of renewable energy by creating favourable (financial) preconditions and by offering a clear and stable policy framework. Fiscal incentives and a ‘greener’ tax system are essential issues in Europe. At the same time, the government tries to create space for more than one supplier by arranging a ‘level playing field’.

A government concern may be the pace of market introduction. The chances for a large-scale market introduction may decrease if the incubation stage lasts too long. In addition, the duration of the incubation stage may be influenced by economic growth at the national and global level.

International research programmes

Different national governments may decide to collaborate with other countries in order to realise their own targets. The synergy of co-operation may lead to a higher cost effectiveness of research and development.

3.1.3 actors on the PV market

Investors/owners

Two types of investors/owners can be distinguished: business oriented investors who are mainly interested in larger systems, and private persons as owners of relatively small systems.

For business oriented investors the return on investment (ROI) will play an important role. The ROI depends upon the interest rate, subsidies, income from energy sales, operation and maintenance costs. Financial engineering and ownership constructions may be complex and therefore form a barrier for the implementation of PV energy systems. The intermittent and relatively unpredictable nature of electricity generation by PV systems may cause the price to be lower than that of electricity from conventional sources. In addition, the income from the sales of the electricity produced is more unpredictable. Fluctuating energy prices in a liberal market, as well as uncertainty about financial incentives may have an impact.

Strategic considerations may play a role: gaining experience with the technology in order to have a competitive advantage in the future, or meeting the demand of customers by supplying them with solar electricity. Also the reliability is an important factor.

Private persons as owners of smaller systems may have other considerations. Status as long as PV systems is expensive. The interest in Status like 'clean' technology, environmental awareness, 'green' image, or an autonomous energy supply system may play an important role. The 'image' factors may play a secondary role for business oriented investors.

An important issue for both categories is the issue of permits by local governments. Time consuming procedures with an uncertain outcome may form an important barrier. In addition, the legal procedures and regulations at different governmental levels are not always clear. All owners are concerned about potential problems with the roof function. Questions may arise of who is responsible for leakage, what happens with the system in case of a roof renovation, etc., especially when system owner and roof owner are not the same party. In addition, a guarantee on the technical functioning is important for owners.

Finally, legal liability may be a major issue, for example in case of accidents during installation, roof repairs, etc. Apart from (safety) standards, also liability insurance is an important matter.

Users

In addition to the above aspects, several issues may be important for the system users, whether they are owners or not. Whereas owners/investors are concerned about the liability in case of leakage, users are especially concerned about the practical consequences of such a leakage.

Another aspect is the possible competition between PV and other 'green' electricity sources. The latter also have the advantage of the 'green' image, but do not have these specific PV disadvantages.

Government (at different levels)

Government bodies at different levels may have interest in PV energy. Targets are often set at a national level. In order to realise these targets, the national government depends upon market parties. Up to now, PV systems has been applied economically in niche markets only. To reach the often ambitious targets, the market penetration of PV systems needs to be accelerated. In the short term, the gap between the real costs and the market price needs to be narrowed. The national government frequently provides financial incentives in order to make investments attractive. These incentives usually have a fiscal character, but may also imply promotion and the removal of non-financial barriers.

Spatial planning is mainly a concern of regional governments. Local authorities, especially, have to deal with issuing permits and local spatial planning. All three levels are influencing the market and have, each in their way, to deal with the issue of regulations and to ensure the compliance with these regulations.

Energy companies
Energy companies play an essential role in the market for PV systems. They have the competence to install PV systems but do not have much roof space available. Furthermore, they have connections with customers in the domestic and industrial sectors who may be interested in buying PV systems and have enough roof space available.

Energy companies could have a strategic interest in the development of PV systems. Their experience with electricity production and distribution and an already existing relationship with their customers give them a better position to market PV systems than project developers.

During the transitional phase to a liberal energy market, electricity and gas consumers in the domestic and commercial sector become 'free' customers. By installing PV systems, energy companies could secure customers before these customers have freedom of choosing a new supplier.

If households were to exploit PV systems on a large scale and deliver the surplus electricity to the grid, electricity companies might face problems. In a number of countries the meter would count backwards, which means that the electricity company would pay the consumer price for the home-made electricity. When an electricity company has a large number of electricity producing customers, it has a disadvantage compared to companies with a small number of such customers. From a technical aspect, the stability of the grid could also be endangered.

Apart from these issues, electricity companies could fulfil an important function in the ownership structures. Firstly, they could act as investors and owners of the systems. Secondly, they could permit their customers to feed back home-produced electricity into the grid and thus establish a new business relationship with their customers. Thirdly, they could also guarantee the (technical) quality of the grid (security of supply, fluctuations in frequency and voltage, over capacity and under capacity, etc.). The electricity distribution companies are often owners of the electricity-producing companies - a structure that does not really fit into a fully liberalised market. Furthermore, electricity distribution companies may become interested in the implementation of PV systems if they are confronted with government imposed targets for renewable energy.

3.1.4 Other actors

Installation companies
Installation companies might see in PV energy a possibility for expansion of their product range. A possible lack of experience with the systems might form a barrier. The installation of the systems requires specific expertise, which is currently not generally available. The interest of skilled installation companies will increase as the cost of PV systems decreases and the market grows. Special professional training, certified systems and so forth could stimulate this interest.

In addition, standardisation could prevent installation companies from having to improvise. Another matter of interest for installation companies might be the accessibility for maintenance and repair. Finally, a certain risk is present in carrying out activities on roofs: modules are relatively fragile, expensive components that are not easy to handle on roofs, especially under windy conditions.

Financial organisations
Financial organisations and institutions provide capital for commercial projects. 'Green' investment funds focus on 'green' projects, including PV projects. In the past years these 'green' funds had a capital surplus, which caused competition between different funds searching actively for new projects and in some cases even initiating projects.

Architects and building contractors
Architects might play an important role in the integration of PV energy in the built environment. They have the option of incorporating PV systems in their designs, although in practice the client will probably make the decision. By applying PV systems in their designs, architects might stimulate the demand for a variety of products (different colours, flexibility, shape, or size).
Integration of PV places restrictions on the architectural design of buildings. On the other hand it could be a challenge for architects to apply PV and make creative and aesthetically successful designs. The lack of PV experience could form a barrier, not only for architects, but also for building contractors. For example, a proper finishing of the edges or the connection of the modules with other roof parts (chimneys, windows, etc.) could cause problems. Standardisation could play an important role in this matter.

Do-it-yourself companies
For do-it-yourself shops and building material businesses PV systems could form an interesting extension of their assortment. Especially for the do-it-yourself market, installation must be kept as simple as possible.

'Ideological' organisations such as Greenpeace or the World Wildlife Fund
The interest of this type of actors in a large-scale market introduction of PV technology arises from their mission. They try to influence the public attitude. For these parties the improvement of the position of non-OECD countries can be an important drive to stimulate widespread use of PV technology.

3.1.5 More general issues

Networks between actors
A network in which all the different parties participate may play an important role in achieving a large-scale market introduction of PV systems. Good communication will lead to a better co-operation and co-ordination of the activities and also stimulate a beneficial competitiveness.

Interaction with other renewable energy options
There are other technical options for electricity production on the market for renewable energy. These technologies may compete with PV for a large-scale market introduction. Possible other options are biomass and (offshore) wind energy. These options might form a threat for PV if they become far more attractive for one reason or another. On the other hand, the general interest in renewable energy may also be very positive for PV.

Interaction with autonomous systems
The application of autonomous systems in OECD countries as well as non-OECD countries may be of importance for the successful market introduction of grid-connected systems. The application of autonomous systems may be important for the economy of scale in the production of components that are used in both system types.

Relation with the global perspective
The critical success factors that influence the large-scale market introduction of grid-connected PV systems are not dependent on developments in one country alone, but must be seen in a global perspective. Factors may also vary per country. For example, in the Netherlands it may be important that PV systems also have a second function (for example, a roof function) in order to be an attractive option. In other countries, with more space and a high solar radiation, this might be less important.

3.2 Conclusions

Based on the inventory in this section, the following list with the most important critical success factors is defined at a somewhat higher level of abstraction.

The confidence in perspectives in the medium to long term
This factor does certainly not involve the perspectives in the sense of 'we feel confident', but rather the argumentation behind this confidence. Manufacturers start with component production because they are expecting a certain (future) market, a demand from the customers, or otherwise. In addition, other actors have their own motivations for having confidence in the developments in the medium or long term.

Development of the investment cost
An important factor for a large-scale market introduction is the expected development of the investment cost.

Technical reliability of (future) PV systems and PV production systems
This factor covers issues such as the reliability of production systems for components and systems, the technical functioning and the energy yield. Especially technical, measurable properties are meant here, including the actual output versus the promised output. Another form of reliability is a sufficient supply of raw materials. When a breakthrough of grid-connected PV systems has been achieved, there must be enough feedstock to guarantee the production of a large volume of systems. In addition, the production facilities during the different stages of production have to function properly. Certification is a tool to establish technical reliability.

Flexibility in product and volume
Different forms of flexibility are involved, for example, a flexible production of different products and flexibility in the production volume. It is expected that different types of grid-connected PV systems will be applied. In addition, the production volume might fluctuate. In the first stage of a breakthrough, a batch-wise demand for PV systems is likely to occur. Companies must be able to absorb such fluctuations in demand.

Research and Development
Fundamental as well as applied research might form an important factor. Is more research necessary or are current PV systems already suitable for application?

Product-market combinations
On the market for grid-connected systems, especially before a large-scale market introduction takes place, a number of specific product-market combinations might become successful. This factor deals with the importance of these first specific applications.

Extent of financial risk
Parties on the PV market will be facing financial risks. The expected return may not be realised, due to lower electricity production (for example, in a year with less sunshine) or unforeseen costs (for example, damage by hail). The profitability is strongly related to these aspects. In addition, the return from electricity sales is also affected by government policy. Financial risk estimates must therefore take into account a wide range of financial and fiscal incentives from the various governmental bodies.

Government policy and incentives
Implementation of grid-connected PV systems touches on many areas of government strategy, for example, energy policy, environmental policy, climate policy, science and technology policy, etc. Governments formulate policies, but how do these policies affect the initial stage of PV introduction? The policies often include various incentives differing in principle and in form.

An important issue is the duration of the incentive. This factor deals with the question how important incentives are in reaching a large-scale introduction of grid-connected PV systems. Developments in this field and uncertainties in the medium term might speed up or slow down plans of actors.

International co-operation
Almost every country in Europe has its own PV programme. International co-operation, or harmonisation of the programmes, may increase or decrease the chance of a breakthrough of PV technology. The synergy from international co-operation might stimulate the realisation of national targets.

Product image
PV technology has a certain image and it may provide a certain status. Showing environmental awareness, or striving for a more autonomous energy supply are examples of status. However, PV may also be considered as decadent. Will the image form a barrier or an incentive in the further breakthrough of PV energy? Will it be possible to use the image factor in order to speed up the breakthrough or to level certain barriers?

Permit procedures
Before installing a PV system, a number of permits usually needs to be applied for. Do the procedures form a barrier to application? Would it be necessary to provide PV with a special status in order to speed up the implementation? In addition, there might be a lack of knowledge at the administrative level. This might lead to longer procedures than necessary.

Liability/responsibility
After installation, a PV system has impact on the surrounding environment. This impact might be in the form of shadow or glittering effects. However, there will also be an impact on the installations to which the PV systems are connected electrically or mechanically. Lack of clarity about responsibility and liability may cause actors on the PV market to be reluctant.

Technical competence
Users and installation companies will have to build up expertise in using and installing PV systems.

Relationship with customers
Electricity companies have an interest in good relationships with their customers. As the process of liberalisation advances, the more important this relationship becomes. In addition, financial institutions like to keep a good relationship with their clients. For these actors, but also for other actors, activities in the field of PV systems may have a positive effect on their relation with the customers.

Investments in stocks and shares
Green funds are becoming increasingly attractive to investors. In some cases, these funds already have a surplus of capital for which it is difficult to find appropriate projects. These funds may be important in the development of a large-scale PV market.

PV as a new product for existing companies
A new product may give companies (for example, installation and maintenance companies) the opportunity to enlarge their sales volume or to offer new services to their customers. The addition of PV products to their product assortment may draw the customer's attention to the existence of this new technology.

Standardisation
This factor concerns the standardisation of the system as a whole, including the size and form of the modules, standard connection and installation equipment, standard inverters, etc. The certification of complete PV systems might be important. Standardisation might facilitate the market introduction of PV systems.

Signal function, stressing the distinctive features
Several organisations are currently praising the distinctive features of PV technology for promotional purposes. These organisations claim that in the medium to long term electricity from PV systems can be economically feasible. These initiatives may accelerate market introduction, but if they are premature, the public opinion about PV may be negatively affected.

Project development/turn-key delivery
Consumers of PV technology vary from do-it-yourself customers to customers who do not have the skills or the time to install the system. In addition, commercial investors may be attracted by the possibility of a turn-key delivery, including financing options and application for subsidies.

The network between actors in the field of PV technology
A strong network is important for a large-scale market introduction. Relevant questions are whether all actors are in contact with each other and whether they are acquainted with each other's work.

The global perspective
In addition to the developments in a certain country or region, global developments in the field of PV are of interest.

The interaction with other renewable energy options
In addition to developments in the field of PV, there are also developments in the field of other renewable energy options, such as biomass and offshore wind energy. These options could lead to competition with PV.

The interaction with the development of a market for autonomous PV systems
The development of the market for stand-alone PV systems may also be important for grid-connected systems. An increase in the production volume of components for stand-alone systems will lead to learning effects and advantages of scale. This will also be advantageous for grid-connected PV as the two systems have many components in common.

Fifteen factors have been derived from the above items and these are examined in the questionnaire. Fourteen factors have been translated into closed questions and one into an essay question. In addition there are two essay questions about 'the most important factor necessary to achieve large-scale market introduction' and 'the most important factor impeding large-scale market introduction'. Finally, the questionnaire is completed with an essay question in which the respondent can add a factor according to his own view. Annex B consists of the original questionnaire and the covering letters.

4. RESPONSE ON THE QUESTIONNAIRE

The selected international PV-experts are classified in three regions: America, Europe and Asia. This classification is made because the aim of this study is to make an international inventory of the most significant factors for turning grid-connected PV into a mature market product. In addition, the study makes an international comparison of the Significance and Status of these factors.

By selecting America, Europe and Asia as regions this study covers the three most important PV developing regions in the world. In this study the American region consists of the United States of America and Canada. The European region consists of the EU15 completed with Norway and Switzerland. The former central planned East European economies and Russia are also included in the European region. The Asian region consists of the countries Japan, South Korea and Australia. Section 4.1 gives an overview of the number of questionnaires sent world-wide. In Section 4.2 the spread in the response is shown. In that section the filled-in questionnaires are sorted according to the mailing option used to return them: by post, fax or Internet. In addition, an extra category is added consisting of useless responses, for example, empty envelopes or blank questionnaires. In the last section the spread of the returned questionnaires is given in absolute numbers as well as in relative numbers.

4.1 Geographical spread of the respondents

The total number of international experts selected to participate in the questionnaire was 262: 185 in Europe, 38 in America and 39 in Asia. A selection from the participants of the Dutch NOZ-PV meetings was added to this number. The 192 NOZ-PV participants selected all have the Dutch nationality and were classified by the project team as PV experts with knowledge of the European PV situation. The European region therefore consists of 377 persons. In total 454 questionnaires were sent, classified in 3 regions. The spread over the world of the PV experts interviewed can be found in Table 4.1.

Table 4.1 *Geographical spread of the interviewed over the different regions*

Region	Number
Europe	377
Asia	39
America	38
Total	*454*

In addition to a classification based on region some other classifications are possible. Theoretically, classifications can be made based on question 1b ‘type of organisation’, 1c ‘main activity of the respondent’ and 1d ‘function of the respondent’, see Annex B ‘questionnaire on the critical success factors for PV’. The ‘type of organisation’ makes it possible to discover if, for example, ‘bankers’ have other ideas than ‘researchers’. The ‘main activity of the respondent’ makes it possible to discover if implementation companies have other concerns than production companies. The ‘function of the respondent’ could reveal differences between management and employees. However, these classifications can not reveal as much information as the classification in regions. Because the PV experts have been selected according to region and not to ‘type of organisation’, ‘main activity of the respondent’ or ‘function of the respondent’, a quantitative analysis and comparison of the numbers of questionnaires sent and returned could only be made per region.

One of the main goals of this study is to discover if there are differences between the regions. Reliable findings can only be reported if the random test size of the region is known. By comparing the random test size and the number of questionnaires returned from a region a correction factor is calculated. A relatively high or low response can thus be corrected. When the random test size is unknown - as it is for 'type of organisation', 'main activity' and 'function' - such a correction cannot be made.

4.2 Geographical spread of the returned questionnaires

Table 4.2 shows the number of returned questionnaires in five different categories. The first three categories are used for analysis. The other two are not used because the questionnaires returned blank cannot be classified and the region 'the Netherlands' is excluded from the analysis.

As mentioned above, the questionnaire did not consider 'the Netherlands' as a region. However, many respondents indicated that their knowledge is specific for the Dutch situation. In our opinion, adding an extra region is not useful within the scope of this project. We therefore decided to leave 'the Netherlands' response out of the analysis. We will treat this region in a separate report especially for the Dutch or the European situation.

The total number of useful questionnaires returned divided by the number of questionnaires sent gives a response of 35.5%, see Table 4.2. The total number of useful international returned questionnaires is 97, a response of 37.0%, which in our opinion is a good score for an unannounced international survey. The response per region shows some differences: Europe 37.3%, Asia 30.8% and America 42.1%, see Table 4.2.

Table 4.2 *Geographical spread of the respondents over the different regions*

Region	Number sent	Number returned	Percentage [%]
Europe	185	69	37.3
Asia	39	12	30.8
America	38	16	42.1
the Netherlands	192	61	31.8
Blank		3	
Total	*454*	*161*	*35.5*
Total international	*262*	*97*	*37.0*

5. DATA TREATMENT AND METHODS OF ANALYSIS

This section gives insight into how the returned data is modified for further analysis. Section 5.1 shows how the information in the questionnaires returned is treated in order to make a SPSS analysis. Section 5.2 describes the analytical methods used for the interpretation of the information. The analytical methods used are tests to evaluate differences in answers between populations. Firstly, the basic principles of the analytical methods used will be described for the questions about Significance and Status. Secondly, the results of the questions 2b, 5b, 7b, 8b, 11b en 14b (see Annex B) needs to be transformed for a consequent analysis. The transformation used is described in Section 5.3. Finally, Sections 5.4 and 5.5 describe two different methods, which can be used to determine a ranking between the factors. To apply SPSS adequately and to select the appropriate tests the following literature has been consulted: Baarda, B.D. et al. (1997), Buis, A. (1995), Hedderson, H. (1991), Noruxis, M.J. (1988) and Oerlemans, L.A.G. (2000).

5.1 Data treatment

SPSS has been chosen as a statistical analysis software tool for analysis of the questionnaires returned. Before starting with the analysis, it is necessary to translate the information on paper into electronic data. Question 1 is translated into numbers corresponding to certain regions, organisations, activities or functions. These numbers are used to select groups of cases for analysis. In Table 5.1 the numbers corresponding to the regions, organisations, activities or functions are presented.

Table 5.1 *Numbers corresponding with region, organisation, activity or function*

Region	*No.*	*Organisation*	*No.*	*Activity*	*No.*	*Function*	*No.*
Blank	0	Blank	0	Blank	0	Blank	0
America	1	Architectural firm	1	RD&D	1	Manager	1
Europe	2	Bank	2	Integration in systems	2	Researcher	2
Asia	3	Consultancy firm	3	& implementation		Director	3
Netherlands	4	Energy company	4	Knowledge transfer	3	Marketeer	4
		Environmental	5	Project development	4	Planning &	5
		organisation		Policy making	5	Guiding	
		Government	6	Product development	6	Advisor or	6
		Project development	7	& design		Consultant	
		Sales & distribution	8	Consulting	7	Design and	7
		Installation	9	Manufacture &import	8	implementation	
		Production or	10	Sales	9	Professor	8
		assembly		Characterisation and	10		
		Institute or university	11	certification			
		Other	12				

The answers to the questions about Significance and Status of the factors in questions 2 to 15 are also translated into a corresponding number. Only one answer is allowed for each of these questions. It is thus possible to calculate several statistical parameters for a group of cases. Also, tests can be performed to discover if there are significant differences or similarities between the regions, see Section 5.2.

Significance or significance
At many places words are written with a capital although these words are not at the beginning of a sentence. This is done to distinguish the Significance of a factor from the significance of a SPSS test result. In consequence also the Status of a factor is written with a capital. Besides Status a factor the Pace of cost reduction, the Current situation of spatial planning & regulation & licensing, the number of initiatives and the Attention for image are written with a capital

The answers to the questions 2, 5, 7, 8, 11 and 14 about the 'aspects' need another form of processing. The options presented in the questions about the aspects can be 'switched on'. With SPSS it is possible to count the number of options that are 'switched on'. This is described in Section 5.3. Comparing the number of options that are 'switched on' per region gives insight into the preferences of these regions. This is done using the analysis method described in Section 5.2. The last option in the questions about aspects is a blank line where the respondent can add his own ideas. These personal ideas formulated by the respondents will be combined with the analysis of the essay questions in Sections 6.16 to 6.19. A card is made for each case containing the answers to the essay questions and the ideas given in the blank line to the question about aspects. The cards also contain the information of the first question about 'personal background'. The essay questions can thus be categorised similarly to the other questions, see Section 4.1.

Annex D presents the basic input for further analysis. Tables D.1 (about the Significance of the factor) and D.2 (about the Status of the factor) contain the number of answers given to the questions 2 to 15 categorised by region. Table D.3 presents the number of answers given to the questions *2b*, *5b*, *7b*, *8b*, *11b* and *14b* about aspects related with the specific factor.

5.2 Kruskal-Wallis and Mann-Whitney tests

The Kruskal-Wallis and Mann-Whitney tests can be used to determine statistically whether two or more grouping variables are different from each other or not. A grouping variable is a variable consisting of a number of cases. In other words, these tests are methods to compare 'populations'. Population is used in statistics to describe a number of cases with a common property. An example is an overall population, which exists of three types of persons, people with long hair, people with short hair and people without hair. The overall population is divided randomly into three sub-populations. To find out whether the sub-populations are the same, a test variable - *x*-cm of hair - is defined. The Kruskal-Wallis and Mann-Whitney tests assume that there is no distinction possible between the sub-populations. If the tests indicate that the sub-populations have a Significant different *x*, it is accepted that the sub-populations can be considered as individual populations. In this example it is logical to make a distinction between people with hair and a population of people without hair.

The Kruskal-Wallis test can be used to discover if the grouping variables come from the same population or not. For this study the three regions, America, Europe and Asia, are the grouping variables and the population is the world. In other words, in this study the Kruskal-Wallis test determines whether the answers given by the respondents are region specific or global. If PV is a world-wide business the answers given in the questionnaire by the 3 grouping variables must be more or less the same.

By comparing three samples with one large population using the Kruskal-Wallis[5] test there is a chance that some details are lost. The risk is that one grouping variable is high, another is average and that the last one is low. They all fit in the total population and are being considered as grouping variables from the same population. However, comparison of the high and the low grouping variables results in the fact that these grouping variables do not come from the same population. This could result for the questionnaire data in the assumption that the answers for the three regions all come from the same population, overlooking the fact that there are significant differences between two regions. To remedy this imperfection the Mann-Whitney test is performed.

It is important to realise that the options ticked in the A-questions are considered to be individual answers. This means that the option 'no opinion' is equally important as the other options. If, for example, an architect has no opinion about the Status of RD&D this answer gives insight into the architect's knowledge and into the PV network. This means that the answer of 'no opinion' is not the same as 'very low' or 'very poor'. All the A-questions are made up of a part informing about the Significance on a three point scale with 'no opinion' being added and a part informing about the Status on a four point scale with 'no opinion' being added.

The non-parametric Mann-Whitney test and the related Wilcoxon test for two independent grouping variables, test the null hypothesis that the grouping variables come from the same population. Rather than being based on parameters of a normal distribution such as mean and variance, Mann-Whitney is based on ranks. The Wilcoxon statistic, *W*, is calculated by ranking the pooled observations of the two grouping variables and obtaining the sum of ranks of the grouping variable with the smaller sample size. The Mann-Whitney statistic, *U*, is obtained by counting the number of times an observation from the grouping variable with the smaller sample size precedes an observation from the larger grouping variable, see Equation 1. The equation for the Mann-Whitney *U* is

$$U = N1N2 + \frac{N1(N1+1)}{2} - T1 \qquad \text{(Equation 1)}$$

where $N1$ and $N2$ are the sizes of the two grouping variables, and $T1$ is the sum of ranks of the grouping variable with the highest mean rank.

The Mann-Whitney *U* and the Wilcoxon *W* are related by equation 2.

$$U + W = \frac{m(m+2n+1)}{2} \qquad \text{(Equation 2)}$$

where *m* is the number of observations in the smaller grouping variable and *n* is the number of observations in the larger grouping variable. Because *U* and *W* add up to a constant, using one of them is equivalent to using the other. Another way of looking at the equivalence between *U* and *W* is that they have the same *z* score. *Z* scores are transformations of the data values to standard deviation units and indicate the relative position of each value within its distribution. The null hypothesis is accepted when the asymptotic significance (2-tailed) is more than 0.05.

[5]The nonparametric Kruskal-Wallis test for more than two independent grouping variables compare the centre of location of the grouping variables. Nonparametric tests are distribution free and do not make the assumption that the populations are normally distributed. The nonparametric tests do assume, however, that the two distributions have the same shape, although this shape does not have to be normal. Kruskal-Wallis tests the null hypothesis that more than two independent grouping variables come from the same population. The statistics are obtained by counting the number of times an observation from the grouping variable with the smaller sample size precedes an observation from the larger grouping variable. When the asymptotic significance is lower than 0.05 the null hypothesis is rejected, meaning that the two grouping variables do not come from the same population.

5.3 Transformation of the questions about methods or aspects

To discover if there are differences between the three regions in the answers to the questions about methods or aspects, a translation is first made. If a respondent has marked more than one of the possible answers, each answer has become a separate case. As a result, these cases are almost identical except for one answer. Table 5.2 is an example of how the different options for question *2b* about financing methods are transformed into numbers. This is done for the 6 questions about methods or aspects.

Table 5.2 *Example of translating questionnaire answers into SPSS numbers*

Questionnaire	SPSS
Lease constructions	1
Pay back tariffs	2
Sale of 'green' power	3
Subsidies	4
Tax measures	5
Other	6

The numbers can be used to construct a histogram in SPSS, which can indicate if there are differences between the regions. The numbers can also be used in the Mann-Whitney test to discover if the given answers differ significantly or not. Each question about methods or aspects has an 'other' category. Here the respondent could formulate his own ideas, which will be given attention when the analytical results are discussed.

5.4 Medal classification for ranking of the factors

One analytical method is the 'Medal classification'. With this method the factor that has 'won the most gold medals' is considered to be the most Significant factor. High is equal to gold, average is equal to silver, low is equal to bronze and no opinion has no colour (which does not mean that it is ignored). To detect which factor is the most Significant, 'high' is gold in this study. If 'no opinion' or 'low' were gold, the factor on position one would be the factor that is least Significant or it could mean that the respondents do not know if the factor is important or not. The same approach for the factor with the number one Status has been followed for this study. The number one rank is the factor that has the best Status, meaning that the situation is good. Therefore, in this study the answer good is marked gold and so on. If two or more factors have 'won' the same amount of 'gold medals' the most important factor is the factor that has won the most 'silver medals'. If the amount of silver medals is also equal, next is bronze followed by no colour. If two factors end on the same position, they both get the same rank. Therefore, it is possible that there are two or more factors with the same rank and the lowest rank is in such a situation not 14 but 13 or even lower.

5.5 The Friedman test for ranking of the factors

The Friedman test is another method. The Friedman test is suitable for respondents who have scored variables on a *x-point scale*, for example, high, average, low and no opinion ($x = 4$). With this test it is possible to compare responses to find out if there are any differences in the Significance of the respondent's preferences. Because the respondents rated each factor, the samples are not independent, and a related-samples test needs to be used. Furthermore, because responses are ratings rather than a continuous measure, these data are not suitable for analysis of variance. The non-parametric alternative to a repeated measure analysis of variance is the Friedman test. Like the Mann-Whitney and Kruskal-Wallis tests, the calculation of the Friedman test is based on ranks within each case. The scores for each variable are ranked and the mean ranks for the variables are compared. The Friedman test is used to test the null hypothesis

that there is no difference in preference between the variables. Equation 3 is the Friedman test equation.

$$\chi^2 = \frac{12}{Kj(j+1)}\left[\sum_j T_j^2\right] - 3K(j+1) \qquad \text{(Equation 3)}$$

where K is the number of sets of matched observations, j is the number of groups, and Tj is the sum of ranks for each group.

6. RESULTS

This section describes the results reached by using the Mann-Whitney test, the Friedman test and the medal classification method. The results are treated per question in a section named after the factor. In these sections the differences or similarities between the respondents answers are presented. Section 6.15 presents the results after ranking the factors on Significance and Status. Finally, Sections 6.16, 6.17, 6.18 and 6.19 present the results from the essay questions.

Significance or significance
At many places words are written with a capital although these words are not at the beginning of a sentence. This is done to distinguish the Significance of a factor from the significance of a SPSS test result. In consequence also the Status of a factor is written with a capital. Besides Status a factor the Pace of cost reduction, the Current situation of spatial planning & regulation & licensing, the number of initiatives and the Attention for image are written with a capital.

6.1 Financing

Question 2 is about the financing of grid-connected PV systems. Figure 6.1 shows the results for Significance of financing according to the regions. The similarity between the shapes of the bars is very strong, especially between America and Europe. The shapes of the Asian bars differ from those of America and Europe. Although there seems to be a difference between America and Europe on the one hand and Asia on the other hand, according to the Mann-Whitney test there is not. The asymptotic significance values are America-Europe = 0.705, Europe-Asia = 0.13 and Asia-America = 0.15. This means that the differences in answers between the regions are not sufficiently significant to assume that the regions should be considered as different populations. Although Figure 6.1 suggests that Asia differ from the other two regions, it does not. The similarity between America and Europe is indisputable. A general conclusion from Figure 6.1 is that the Significance of financing is high in all the regions, America and Europe higher than 80% and Asia more than 60%.

Figure 6.2 shows the Status of financing in the regions. A first impression could be that all the three regions differ from each other. A more detailed consideration of the figure shows that America and Europe are normally distributed and Asia is not. It is therefore plausible that America and Europe differ from Asia, although it is still possible that America and Europe differ. According to the Mann-Whitney test there is a significant difference between Europe-Asia and Asia-America. The asymptotic significance values are America-Europe = 0.138, Europe-Asia = 0.039 and Asia-America = 0.003. This means that the Status of financing in Asia is different from America and Europe. A general conclusion from Figure 6.2 and the Mann-Whitney test is that the Status of financing is insufficient in all the regions. In Asia, however, the Status is relatively better than in the other two regions, stressed by the fact that the bars for ‘good’ and ‘sufficient’ are very high (27.25%) compared to America and Europe.

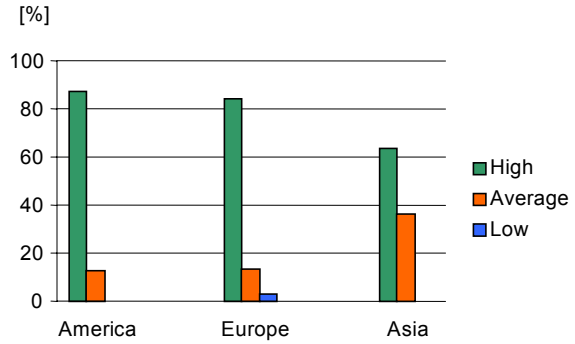

Figure 6.1 *Significance of financing*

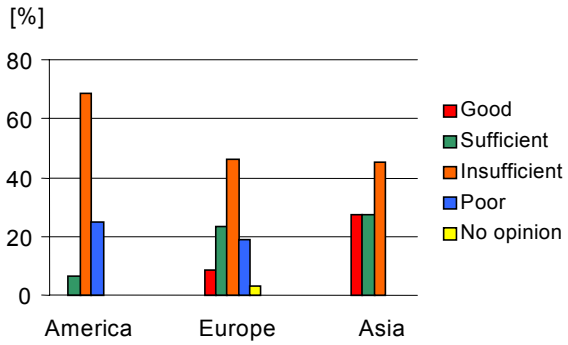

Figure 6.2 *Status of financing*

Figure 6.3 shows the spread in answers to the question about the preference for financing methods. The shapes of the histograms are generally the same, therefore it may be assumed that there are no significant differences. In Europe the answers are concentrated on four items; in America and Asia on three. The 'pay back tariffs' and 'sale of 'green' power' are the main answers for Europe while 'subsidies' and 'tax measures' are the main answers for America and Asia. In spite of this, the differences are not likely to be significant.

The Mann-Whitney test indeed indicates that the differences are too small to be significant. The calculated values are America-Europe = 0.135, Europe-Asia = 0.144 and Asia-America = 0.76. These values confirm the first impression that the resemblance between Asia and America is much stronger than the resemblance between Europe and America or Asia.

The suggestions made by the respondents in 'other financing methods' show some differences between the regions. Only one of the American respondents made a suggestion. According to this person 'rate-based incentives' are important financing methods for achieving large-scale application of grid-connected PV systems. The European respondents made some specific suggestions based on the options in the questionnaire. Examples are: tax measures for a period of 10 years, a combination of lease constructions with pay back tariffs or subsidies at a low level, like in the 100.000 roof programme in Germany. It is remarkable that 'rate-based incentives' comes from America. Asia, like America, gave only one suggestion: the 'green energy credits' should go to the manufacturers of PV systems to enable them to reduce PV prices for customers.

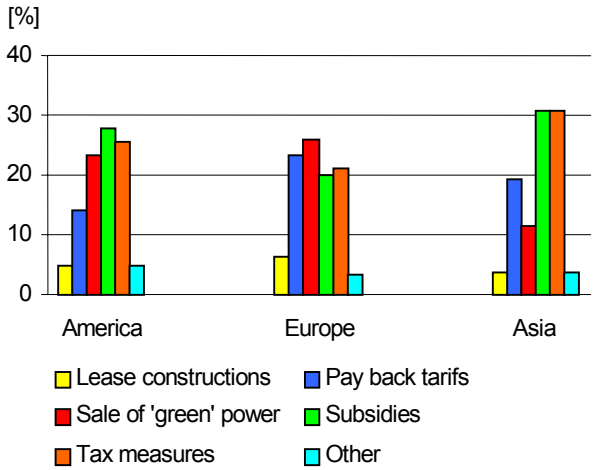

Figure 6.3 *Preference for financing methods*

6.2 Cost reduction

Question 3 is about cost reduction of PV. Figure 6.4 shows the results of the Significance of cost reduction in the regions. The first impression is that America and Europe differ from Asia as indicated by the bars for 'high' and 'no opinion'. It also is remarkable that 25% of the respondents in Asia had 'no opinion' about the cost reduction while none of the respondents in America and Europe ticked 'no opinion'. The bars for 'high' are more than 80% in America and Europe while Asia scores 50%. According to the Mann-Whitney test there is a significant difference between Europe-Asia and Asia-America, the asymptotic significance values are America-Europe = 0.692, Europe-Asia = 0.002 and Asia-America = 0.052. Although the asymptotic significance value for Asia-America is larger than 0.05 the visual similarity of America and Europe is large enough to accept that the difference between America and Asia can be considered as significant. A general conclusion is that in Asia the interest in or awareness about cost reduction is less than in America and Europe. The higher Status of financing in Asia might be the explanation for this result, see Figure 6.1.

Figure 6.5 shows the results of the Pace of cost reduction in the regions. It is obvious that the Pace of cost reduction is the same for all the regions. The respondents are of the opinion that it is 'not fast enough', although Asia is somewhat more optimistic than the other regions. According to the Mann-Whitney test there is no difference between the three regions. The asymptotic significance values are America-Europe = 0.494, Europe-Asia = 0.42 and Asia-America = 0.236. The general conclusion is that the Pace of cost reduction is considered not fast enough everywhere in the world.

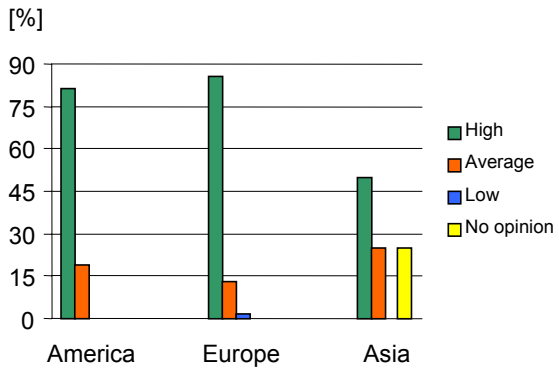

Figure 6.4 *Significance of cost reduction*

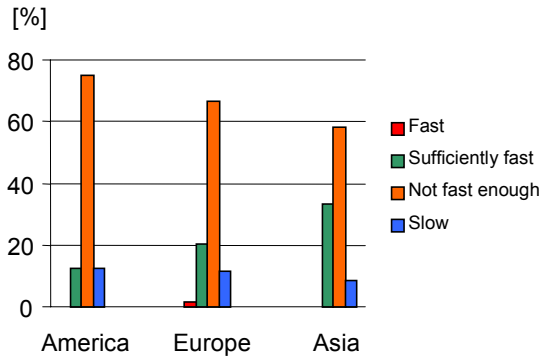

Figure 6.5 *Pace of cost reduction*

6.3 Spatial planning, regulation and licensing

Question 4 is about the role of spatial planning, regulation and licensing. Figure 6.6 shows the results of Significance of spatial planning, regulation and licensing in the regions. Figure 6.6 gives the impression that America and Asia differ because in America more than 60% has chosen 'average' and in Asia more than 60% 'high'. Europe can be seen as the average of America and Asia. It may therefore be assumed that only America and Asia will be significantly different according to the Mann-Whitney test. However, according to the Mann-Whitney test there is no significant difference between the regions. The asymptotic significance values are America-Europe = 0.42, Europe-Asia = 0.452 and Asia-America = 0.287. Statistically this result is correct although human logic would seem to deny it. The small sample size of Asia might be an explanation for this remarkable result. As long as there is no satisfying explanation for the result, the answers of the different regions are equal. The respondents think on average that the Significance of spatial planning, regulation and licensing is average to high.

Figure 6.7 shows the results of the Current situation in spatial planning, regulation and licensing in the regions. The situation seems more or less the same in the regions. The minor differences are probably not large enough to be significant. According to the Mann-Whitney test there is

indeed no significant difference between the regions. The asymptotic significance values are America-Europe = 0.639, Europe-Asia = 0.536 and Asia-America = 0.869. This means that the answers given in the three regions can be considered as equal. Another conclusion is that the respondents on average think that the current situation for spatial planning, regulation and licensing is not favourable enough.

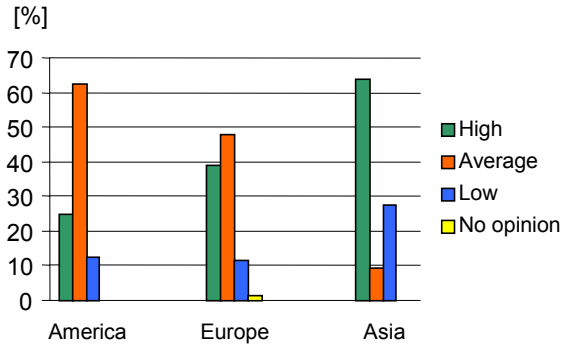

Figure 6.6 *Significance of spatial planning, regulation and licensing*

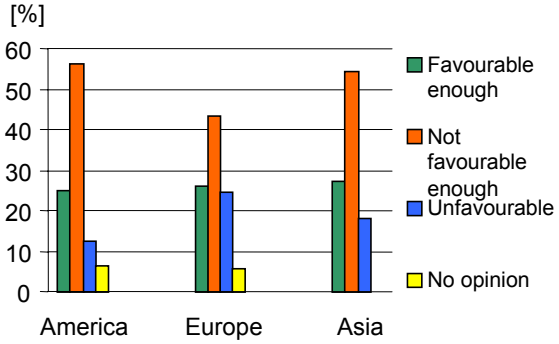

Figure 6.7 *Current situation in spatial planning, regulation and licensing*

6.4 Other elements influencing market introduction

Question 5 is about the role of other elements influencing market introduction. Figure 6.8 shows the results of the Significance of other elements influencing market introduction in the regions. The answers of the respondents are generally more or less the same for the regions, that is to say, the visual differences are probably too small to be significant. The chance of a significant difference is probably largest for America and Asia. However, according to the Mann-Whitney test, there is no significant difference between the regions. The asymptotic significance values are America-Europe = 0.201, Europe-Asia = 0.78 and Asia-America = 0.311. A more detailed inspection of the bars in Figure 6.8 reveals that the results are concentrated around average. The American and European respondents gave 'average' the highest percentile while the Asian respondents gave it the lowest percentile. The Asian respondents gave 'high' and 'low' a high percentile so that the end result is also 'average'. The spread in answers is wider for Asia but apparently not sufficiently wide to reject the hypothesis that the regions' answers are the same.

Figure 6.9 shows the results of the Number of initiatives influencing market introduction in the regions. Figure 6.9 gives the impression that the regions differ significantly from each other. America's answers are highly concentrated on 'insufficient', Europe's are normally distributed and Asia's are equally spread over 'sufficient', 'insufficient' and 'few'. However, according to the Mann-Whitney test, there is no significant difference between the regions. The asymptotic significance values are America-Europe = 0.166, Europe-Asia = 0.348 and Asia-America = 1.0. The situation for Asia-America and Europe-Asia can be compared with the situation for Asia-America in Figure 6.7. Even the samples for America and Europe could be taken from different populations, statistically the samples are from the same population. However, this result is controversial. The fact that there is no significant difference statistically, despite totally different shapes, is probably caused by the mean. The mean for this question is concentrated around 'insufficient' for each region. It may be concluded that on average all the respondents regard the Number of the initiatives influencing market introduction insufficient. But the American respondents are the most unanimous in their opinion.

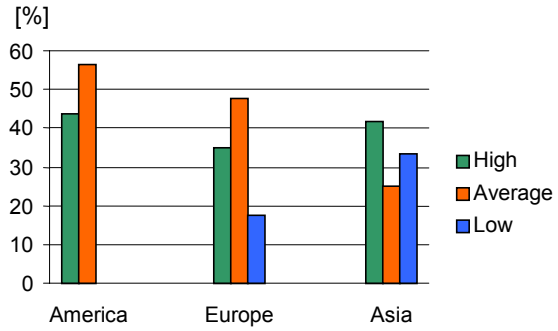

Figure 6.8 *Significance of other elements influencing market introduction*

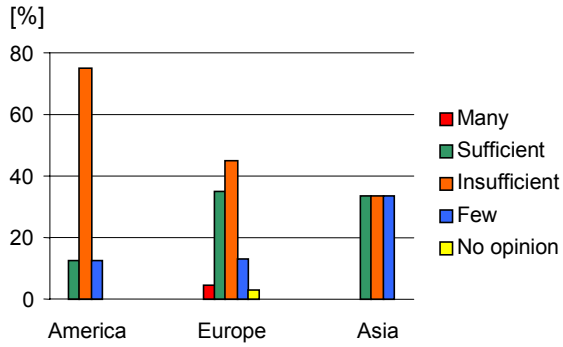

Figure 6.9 *Number of initiatives influencing market introduction*

Figure 6.10 shows the spread in answers to the question about the type of activities influencing market introduction in the three regions. The shapes of the histograms are generally the same for America and Asia. In both regions the 'pioneering activities' are seen as the most important activity to improve the market introduction of PV. In Europe the answers are much more spread out over the five options. It is, however, uncertain if the differences between Europe on the one hand and America and Asia on the other hand are sufficiently large to be significant.

The Mann-Whitney test, however, indicates that only the difference between Europe and Asia is sufficiently large to be significant. The calculated value for Europe-Asia is 0.024; the values for America-Europe and Asia-America are 0.184 and 0.406. This confirms the first impression that the resemblance between Asia and America is much larger than the resemblance between Europe and America or Asia. It also confirms that the histogram for America resembles the histogram for Asia.

A suggestion made by an American respondent is in fact a further specification of 'pioneering activities'. This person believes that 'pioneering activities by organised consumer groups' could be an important activity influencing market introduction. It is remarkable that a European respondent also makes the same suggestion. Another European respondent suggests 'large-scale demonstration'. European respondents mentioned two initiatives more than once, 'integration of PV in buildings' and 'initiatives by local utilities'. Suggestions from Asian respondents are 'public education', 'demonstration systems' and 'governmental sponsored schemes'. The suggestion made by a European respondent of 'large-scale demonstration' is almost identical to the 'demonstration systems' suggested by an Asian respondent.

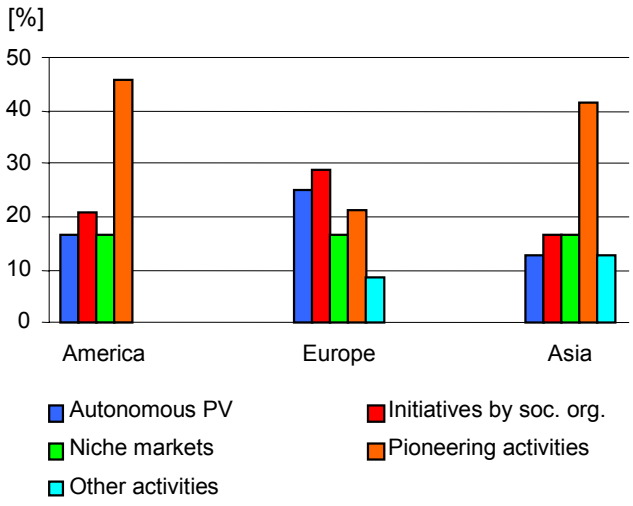

Figure 6.10 *Activities influencing market introduction*

6.5 Environmental merits

Question 6 is about the environmental merits of PV. Figure 6.11 shows the results of the Significance of environmental merits of PV in the regions. It is likely that the answers given by the American respondents differ significantly from the answers given by the European respondents. Europe may even be significantly different from Asia. However, according to the Mann-Whitney test the difference between America-Europe is not significant, because the asymptotic significance value is 0.055. The values are for Europe-Asia 0.419 and for Asia-America 0.453. Although the asymptotic significance value for America-Europe is larger than 0.05, the difference is accepted in this case as a significant difference. This is because the respondents in Europe express most explicitly their preference for 'high'. This means that the answers from the American respondents are different from the answers from the European respondents. It may be concluded that the European respondents have the most explicit opinion and the American and Asian respondents vary between 'high' and 'average'.

Figure 6.12 shows the results of the Status of environmental merits of PV in the regions. According to Figure 6.12 Europe and Asia are almost equal. The answers given by America are probably not different from the other regions. According to the Mann-Whitney test there is indeed no significant difference between the regions. The asymptotic significance values are America-Europe = 0.799, Europe-Asia = 0.293 and Asia-America = 0.343. A conclusion is that the Asian respondents are most optimistic about the environmental merits because the 'good' bar scores 30%. The American and European respondents are somewhat less optimistic about the environmental merits.

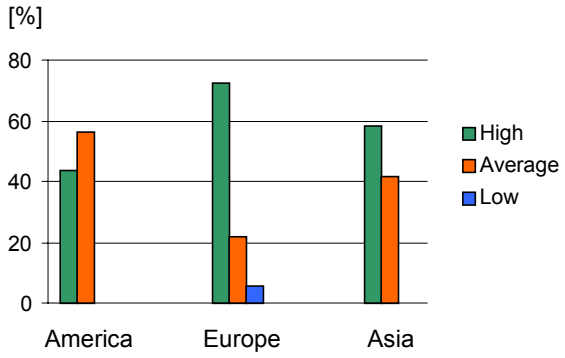

Figure 6.11 *Significance of environmental merits*

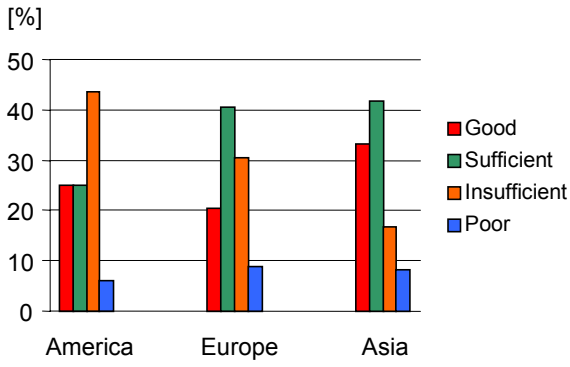

Figure 6.12 *Status of environmental merits*

6.6 Technical reliability

Question 7 is about the technical reliability of PV systems. Figure 6.13 shows the results of the Significance of technical reliability in the regions. A division into the group America/Europe and the Asian group is immediately visible. The visual difference between these groups is sufficiently large to expect a significant difference between America and Europe in relation to Asia. However, according to the Mann-Whitney test there is only a significant difference between Europe-Asia. The asymptotic significance values are America-Europe = 0.672, Europe-Asia = 0.005 and Asia-America = 0.085. Although the asymptotic significance value for Asia-America is 0.085, the similarity with Europe-Asia is large enough to accept a significant difference between Asia-America. This means that the Asian sample is taken from another population than the samples of America and Europe. Regarding this difference it is logical to conclude that the respondents in America and Europe consider technical reliability highly important, while in Asia it is the mean of high and average.

Figure 6.14 shows the results of the Status of technical reliability in the regions. Figure 6.14 gives the impression that there are differences between the regions, especially between Europe and Asia. Surprisingly, the asymptotic significance values are America-Europe = 0.566, Europe-Asia = 0.175 and Asia-America = 0.225. According to the Mann-Whitney test, this indicates that there is no significant difference between the three regions. Although the asymptotic significance values are much larger than 0.05, some remarkable differences must be mentioned. The respondents in Europe have a preference for 'sufficient'. In Asia the respondents tend to be more optimistic than the respondents from Europe, in America they tend to be slightly more pessimistic than the European respondents. It is probably because the mean values are more or less the same that the Mann-Whitney test does not indicate any significant differences.

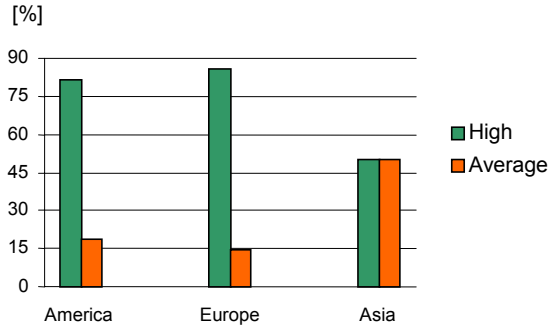

Figure 6.13 *Significance of Technical reliability*

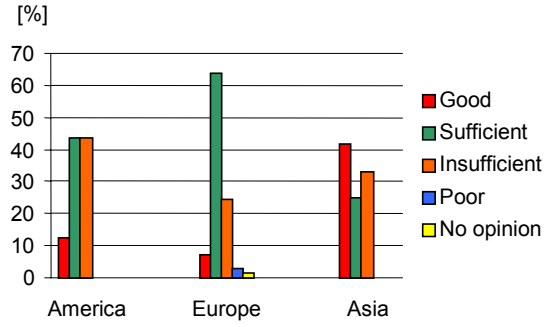

Figure 6.14 *Status of Technical reliability*

Figure 6.15 shows the spread in answers to the question about the technical reliability aspects in the three regions. The shapes of the histograms are generally the same. Asia is somewhat different from the other regions, but the difference is probably not sufficient to be significant. In general the respondents from America and Europe consider 'certification & standardisation' and 'guarantees' as the most important aspects, while the respondents in Asia consider 'certification & standardisation' as the most important aspect. The Mann-Whitney test confirms the impression that the differences between the regions are too small to be significant. The calculated values are America-Europe 0.628, Europe-Asia 0.446 and Asia-America 0.838.

The suggestions made by the American respondents can be summarised in 'more and better tests', 'specific tests for input and output devices' and 'integrated systems tests'. The European respondents make almost the same suggestions by mentioning 'installer training' and 'maintenance contracts'. The Asian respondent's suggestions are more reliability on 'volume production' and 'training in the PV power trade.

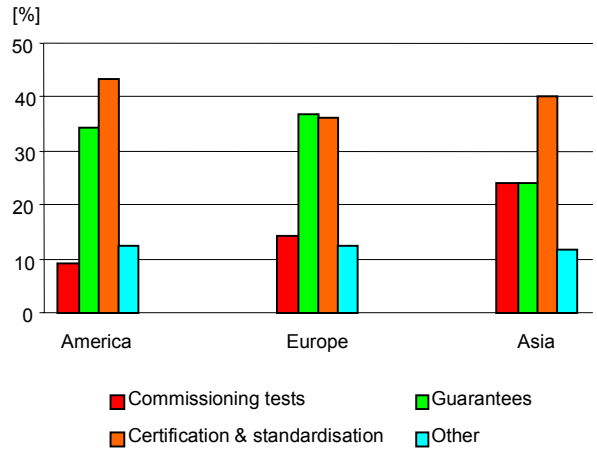

Figure 6.15 *Technical reliability aspects*

6.7 Product diversity

Question 8 is about the product diversity of PV systems. Figure 6.16 shows the Significance of product diversity in the regions. The differences between the histograms are probably too small to be significant. According to the Mann-Whitney test, there is no significant difference between the regions. The asymptotic significance values are America-Europe = 0.213, Europe-Asia = 0.787 and Asia-America = 0.517. This means that the three samples are taken from the same population. All the regions rate the Significance of product diversity as 'high' or 'average'.

Figure 6.17 shows the results of the Status of product diversity of PV systems in the regions. Although the situations in America, Europe and Asia are not the same, it is doubtful whether the differences are significant. If there is a significant difference, it must be the difference between America and Asia. According to the Mann-Whitney test there is no significant difference between the regions. The asymptotic significance values are America-Europe = 0.289, Europe-Asia = 0.648 and Asia-America = 0.225. It may be concluded that all three regions consider product diversity as 'insufficient' in the first place, 'sufficient' in the second place and 'poor' in the third place.

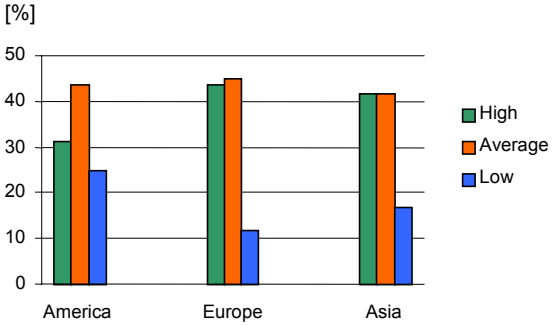

Figure 6.16 *Significance of product diversity*

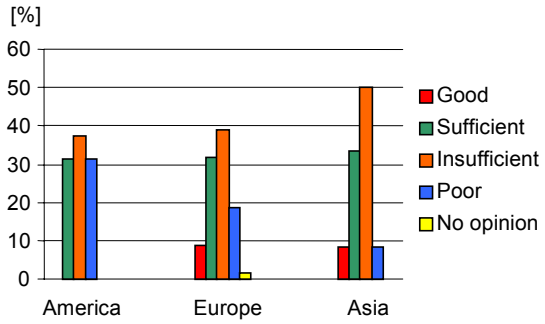

Figure 6.17 *Status of product diversity*

Figure 6.18 shows the spread in the answers about the preference for diversity in the three regions. The shapes of the histograms are generally the same. The respondents in each region consider 'mounting' as the most important aspect. There is a difference between America/Europe and Asia regarding the second place. America and Europe consider 'dimension (length/width)' as the second most important aspect, whereas the Asian respondents considers 'power (Wp)' as the second most important. This difference is probably not sufficient to be significant.

The Mann-Whitney test indeed indicates that the differences between the regions are too small to be significant. The calculated values are America-Europe 0.937, Europe-Asia 0.486 and Asia-America 0.608. These values confirm the first impression that the resemblance between Asia and America is much larger than the resemblance between Europe and America or Asia.

The American respondents stresses the importance of 'colour' and dimension' of PV systems for building integration. Additional suggestions come from European respondents such as 'integration with small systems (cord less)', 'packaging with other (roof) components' and 'shape (form and application) of the systems'. But there also are respondents who point out that as long as the cost is high, diversity is not an issue. An Asian respondent suggests the 'ease of installation' as being an important diversity aspect.

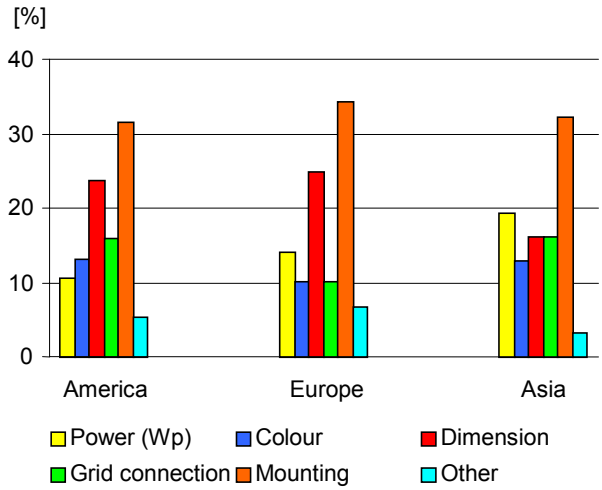

Figure 6.18 *Preferences for diversity*

6.8 Standardisation

Question 9 is about standardisation for implementation of PV systems. Figure 6.19 shows the Significance of this factor. The situation in the regions is almost identical; all the respondents consider standardisation to be highly important. According to the Mann-Whitney test, there is no significant difference between the regions. The asymptotic significance values are America-Europe = 0.918, Europe-Asia = 0.963 and Asia-America = 0.915. This means that the three samples are taken from the same population.

Figure 6.20 shows the Status of the standardisation for implementation of PV systems in the regions. According to the Mann-Whitney test there is a significant difference between Europe-Asia. The asymptotic significance values are America-Europe = 0.497, Europe-Asia = 0.039 and Asia-America = 0.143. It is remarkable that the difference between Asia and America is not significant, while it is significant for Europe and Asia. Visual inspection of Figure 6.20 suggests that the difference between Asia-America is large enough to be significant. The significant difference is probably caused by the larger spread in the European answers than in the American. The European answers are spread over 4 options, the American over 3 options and the Asian only over 2 options. The American and European respondents regard the Status of standardisation as 'insufficient' while the Asian respondents are somewhat more optimistic about the Status.

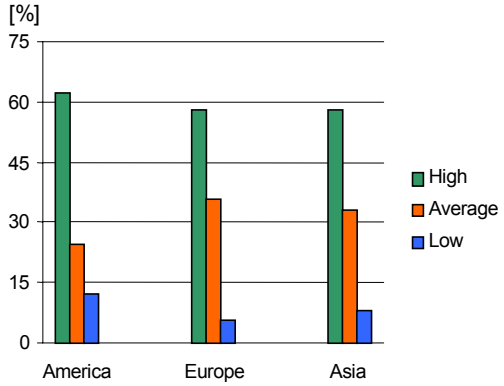

Figure 6.19 *Significance of standardisation*

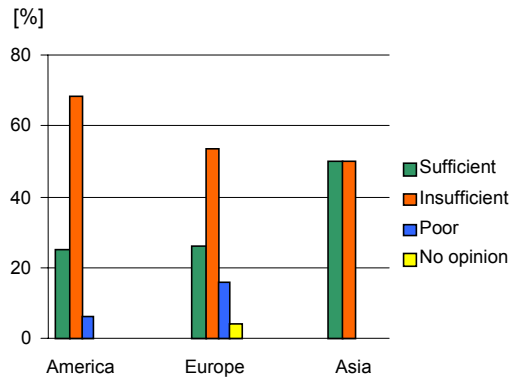

Figure 6.20 *Status of standardisation*

6.9 Specialised knowledge

Question 10 is about specialised knowledge of PV systems and PV installation. Figure 6.21 shows the Significance of specialised knowledge of PV systems and PV installation techniques and procedures in the regions. Figure 6.21 gives the impression that there are no remarkable differences between the regions. According to the Mann-Whitney test there is indeed no significant difference between the regions. The asymptotic significance values are America-Europe = 0.211, Europe-Asia = 0.721 and Asia-America = 0.612. This leads to the conclusion that the three samples are taken from the same population and that all the respondents consider specialised knowledge of PV systems and PV installation techniques and procedures as highly important for large-scale grid-connected PV systems.

Figure 6.22 shows the Status of specialised knowledge of PV systems and PV installation in the regions. The histograms indicate that there is a large difference between America and Europe on the one hand and Asia on the other hand. According to the Mann-Whitney test, there is only a significant difference between Europe-Asia. The asymptotic significance values are America-Europe = 0.197, Europe-Asia = 0.009 and Asia-America = 0.134. It is surprising that the asymptotic significance value for Asia-America is not significant. The histogram for America is the opposite of the histogram for Asia. This may be due to the fact that the respondents in America and Asia gave only two types of answers. Perhaps, only in very extreme situations, small sample sizes could be considered significantly different by SPSS. In short, the respondents in Asia consider the specialised knowledge as 'poor', while the respondents in America and Europe consider specialised knowledge as 'insufficient'.

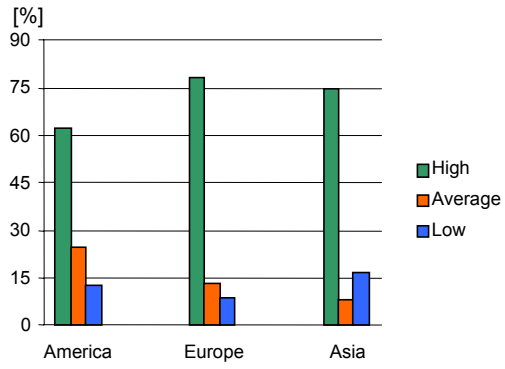

Figure 6.21 *Significance of specialised knowledge*

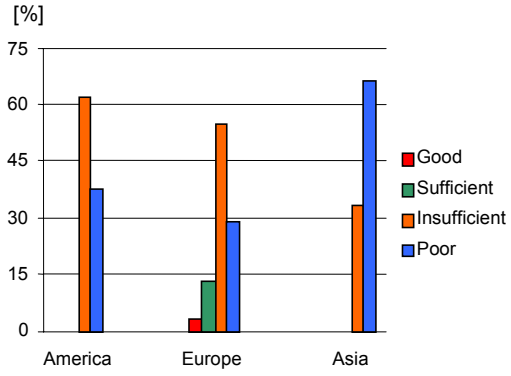

Figure 6.22 *Status of specialised knowledge*

6.10 Image

Question 11 is about the image of PV for grid-connected applications. Figure 6.23 shows the Significance of image in the regions. The differences between the regions are not large, definitely not large enough to be significant. According to the Mann-Whitney test, there is no significant difference between the regions. The asymptotic significance values are America-Europe = 0.931, Europe-Asia = 0.699 and Asia-America = 0.726. The main conclusion in Figure 6.23 is that all the respondents consider image to be a highly important aspect of PV systems.

Figure 6.24 shows the attention for image of PV systems in the regions. The shape of the histograms differs slightly in the three regions. Probably only the difference between America and Asia is significant. Surprisingly, according to the Mann-Whitney test, there is a significant difference between America-Europe and Asia-America. The asymptotic significance values are America-Europe = 0.008, Europe-Asia = 0.254 and Asia-America = 0.003. Although the histograms for America and Europe are considerably different, statistically they are not. This is probably caused by the fact that the American respondents have no answers in the category

'good'. The criteria for America-Europe are therefore different from Asia-Europe. There are also some differences in the peak, because the American respondents rates the attention as 'insufficient', the European respondents shows a virtual average of 'sufficient' and 'insufficient' and the Asian respondents considers it as 'sufficient'.

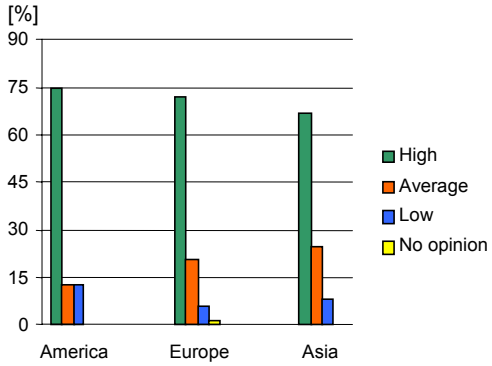

Figure 6.23 *Significance of image*

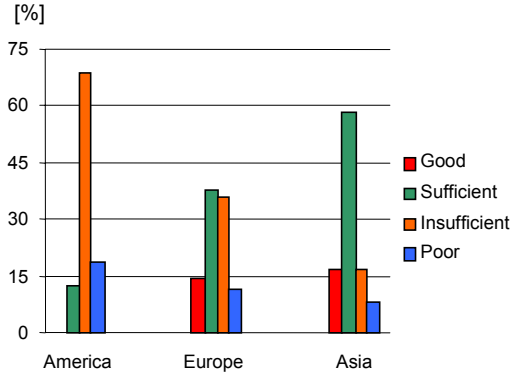

Figure 6.24 *The attention for image*

Figure 6.25 shows the spread in answers to the question about preference on image aspects in the three regions. The shapes of the histograms are generally the same. The respondents in each region consider 'environment' as the most important Image aspect. There are some differences between the other aspects in the regions. America and Europe have shapes that are more or less the same. Asia differs somewhat from these two regions. This difference is probably not enough to be significant.

The Mann-Whitney test indeed shows that the differences between the regions are too small to be significant. The calculated values are America-Europe: 0.776, Europe-Asia: 0.884 and Asia-America: 0.775. These values do not confirm the initial impression that the resemblance between America and Europe is larger than the resemblance between Asia and America or Europe.

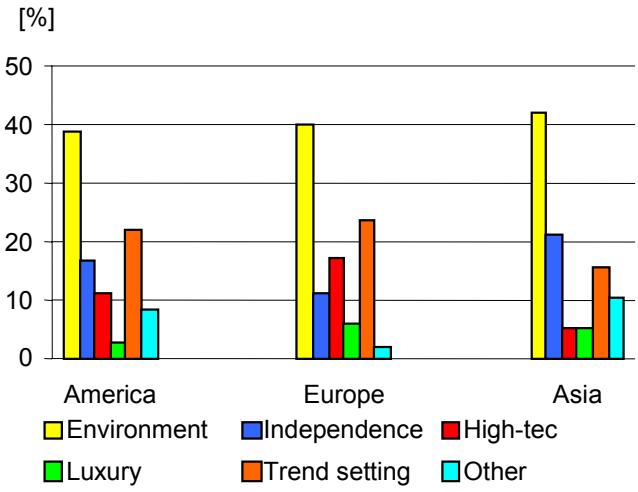

Figure 6.25 Preference on image aspects

The American respondents suggest that 'aesthetics' and the 'competitiveness with utility' are also important aspects of image. Some Europe respondents mention the 'reliability as a building element' and others believe that the importance of image will decline when the PV systems become cheaper. Aesthetics, suggested by American respondents, is also mentioned by Asian respondents who furthermore add 'the socially right thing to do'.

6.11 The role of RD&D

Question 12 is about the role of RD&D in the PV sector. Figure 6.26 shows the Significance of RD&D in the PV sector in the regions. The first impression from Figure 6.26 is that Asia differs from America and Europe. However, according to the Mann-Whitney test, there is no significant difference between the regions. The asymptotic significance values are America-Europe = 0.514, Europe-Asia = 0.12 and Asia-America = 0.085. It is difficult to find an explanation for the fact that the differences are not significant. Maybe the 'high' bars for America and Europe must surpass 90% to be significantly different. Although the difference is not significant, there is a difference because the respondents from America and Europe rate RD&D as highly important, while the Asian respondents score a virtual mean between 'high' and 'average'.

Figure 6.27 shows the Status of RD&D for PV in the regions. Because the shapes of the histograms differ in many respects it is plausible that the three regions must be considered as separate populations. According to the Mann-Whitney test, the differences between America-Europe, Europe-Asia and Asia-America are significant. The asymptotic significance values are America-Europe = 0.022, Europe-Asia = 0.026 and Asia-America = 0.001. In addition to the fact that the samples are taken from three different populations, the peaks are also different for each population. The respondents from America find the Status of RD&D 'insufficient', the European respondents find it 'sufficient/insufficient' and the Asian respondents 'sufficient'.

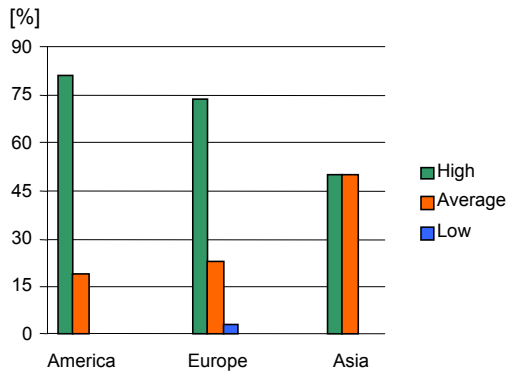

Figure 6.26 *Significance of RD&D*

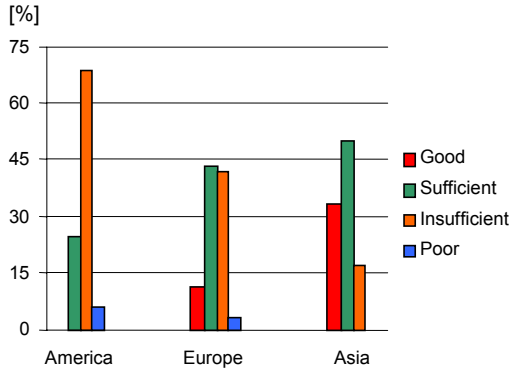

Figure 6.27 *Status of RD&D*

6.12 Technical/commercial network

Question 13 is about the technical/commercial network in the PV sector. Figure 6.28 shows the Significance of the technical/commercial network in the PV sector in the regions. The figure indicates that there are no significant differences to be expected. According to the Mann-Whitney test, there is indeed no significant difference between the regions. The asymptotic significance values are America-Europe = 0.75, Europe-Asia = 0.111 and Asia-America = 0.104. It may be concluded that all respondents consider the technical/commercial network of 'high/average' importance for large-scale grid-connected PV systems.

Figure 6.29 shows the Status of the technical/commercial network in the PV sector in the regions. The different peak for America is conspicuous. A closer inspection reveals some smaller differences between the regions. America seems significantly different from Europe and Asia. According to the Mann-Whitney test, there is only a significant difference between Asia-America. The asymptotic significance values are America-Europe = 0.176, Europe-Asia = 0.116 and Asia-America = 0.038. Surprisingly, the difference between the American and European answers is not significant. An explanation cannot be given. The peaks are definitely different, the American respondents find the technical/economical network 'sufficient', while the European and Asian respondents find it 'insufficient'. Europe tends a little more towards 'sufficient' while Asia tends more towards 'poor'.

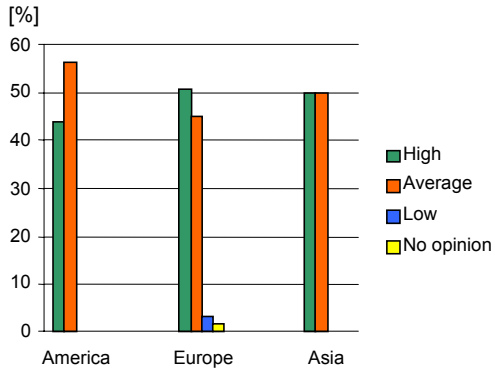

Figure 6.28 *Significance of the PV network*

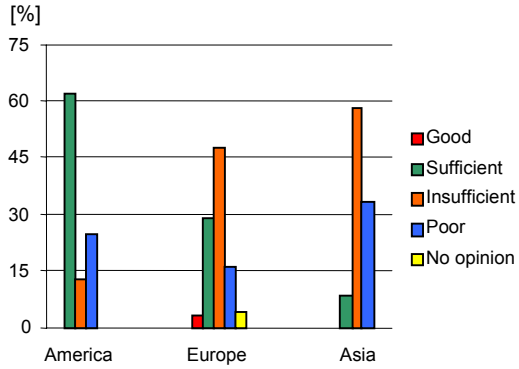

Figure 6.29 *Status of the PV network*

6.13 Internationalisation

Question 14 is about internationalisation. Figure 6.30 shows the Significance of internationalisation in the regions. The figure reveals a small difference between America and Europe. It is difficult to say whether the difference between Europe and Asia is significant or not, the shape of the bars is different but the ranking of the bars is the same. The difference between Asia and America might be significant. According to the Mann-Whitney test, there is no significant difference between the regions. The asymptotic significance values are America-Europe = 0.634, Europe-Asia = 0.182 and Asia-America = 0.354. It is remarkable that the difference between Asia-America is not significant. Although the differences are not significant, there is a difference between the peaks. The American and European respondents both score internationalisation average between 'high and average' Significant in reaching large-scale grid-connected PV-systems, while the Asian respondents score it 'highly' Significant.

Figure 6.31 shows the Status of internationalisation in the regions. It is not very likely that there is a significant difference between any of the regions. However, Asia is somewhat different from the other regions. According to the Mann-Whitney test, there is no significant difference between the regions. The asymptotic significance values are America-Europe = 0.806, Europe-Asia = 0.382 and Asia-America = 0.341. The peaks are also the same in the three regions; they are all concentrated around 'sufficient/insufficient' with the smallest spread for Asia and the largest for Europe. The spread appeared not large enough for significant differences.

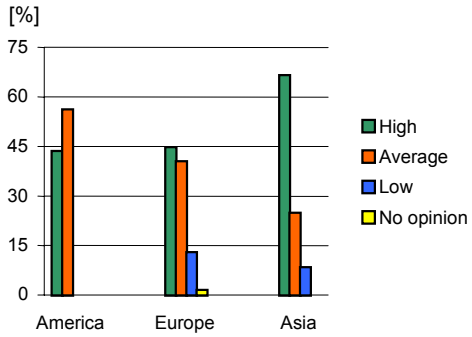

Figure 6.30 *Significance of internationalisation*

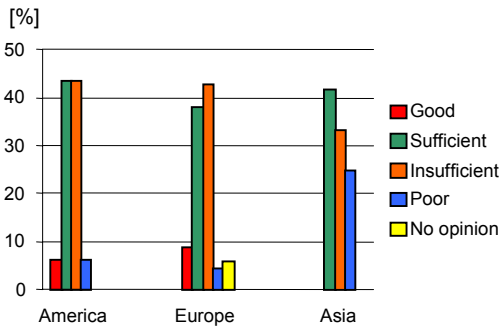

Figure 6.31 *Status of international co-operation*

Figure 6.32 shows the spread in answers to the question about the forms of international collaboration. The shapes of the histograms for America and Europe are amorphous and for Asia more triangular. If there is any significant difference, it must be the difference between America and Europe on one side and Asia on the other side. However, it is likely that the differences are too small to be significant. The large number of categories shown in Figure 6.32 is probably the reason for the difficulty in making any distinction between the regions.

The Mann-Whitney test, however, indicates that the difference between Europe and Asia is large enough to be significant. The calculated value for Europe-Asia is 0.017, the values for America-Europe and Asia-America are 0.603 and 0.126. It is remarkable that the difference between Europe and Asia is that strong, while the critical value is >0.05. It also is remarkable that the answers given by the American respondents are not significantly different from the answers given by the Asian respondents. Finally, the calculated value for America-Europe confirms the first impression that the resemblance between the American and European respondents is much larger than the resemblance between the Asian respondents and the American or European respondents.

From an American respondent comes the suggestion for 'more standardisation' in the field of international co-operation. Development aid is also mentioned with the side-note that aid should be given to a few specific countries. Some European respondents suggest that an 'open market within EU' is important and that 'regulation of grid-connection must be harmonised'. Like American respondents, European respondents also suggest 'more standardisation' in the field of international co-operation. Some European respondents think that internationalisation is not an issue anymore, because the main companies active in PV are already multinationals. Finally, an Asian respondent suggests more attention for the exchange of information and experience.

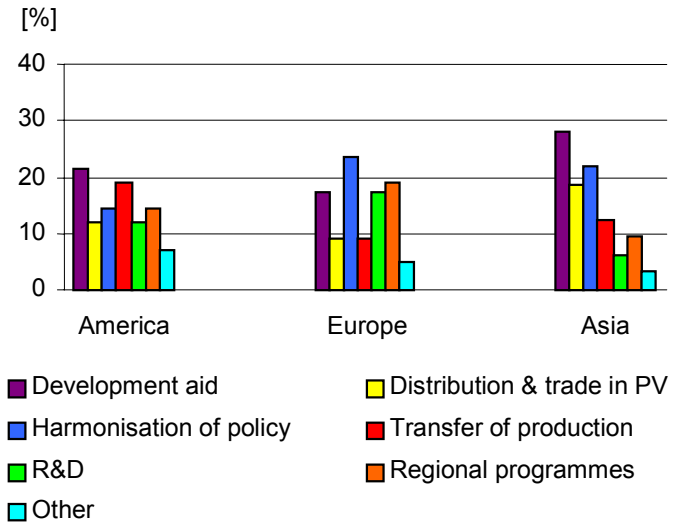

Figure 6.32 *Forms of international collaboration*

6.14 Global developments

Question 15 is about global developments in the PV sector. Figure 6.33 shows the Significance of global developments in the PV sector in the regions. The first impression is that there are no large differences between the three regions. There is a possibility that the difference between Asia and America is significant, caused by the spread in responses. The Asian respondents gave answers in 2 of the 4 possible categories, while the respondents in America gave answers in all 4 of the possible categories. According to the Mann-Whitney test, there is no significant difference between the regions. The asymptotic significance values are America-Europe = 0.687, Europe-Asia = 0.276 and Asia-America = 0.248. The respondents for the three regions all agree that global developments are of 'high' Significance.

Figure 6.34 shows the Interaction between global developments in the PV sector in the regions. Looking at Figure 6.34, it seems that there is a difference between Europe and Asia on the one side and America on the other side. The answers for America have a triangular shape, while Europe and Asia are normally distributed. Beside the shape, the American answers peak at 'sufficient' while the European and Asian answers peak at 'insufficient'. However, according to the

Mann-Whitney test there is no significant difference between the regions. The asymptotic significance values are America-Europe = 0.208, Europe-Asia = 0.212 and Asia-America = 0.901. It is remarkable that America does not differ significantly from Europe and Asia.

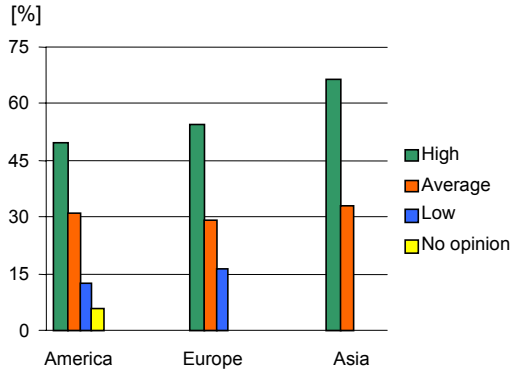

Figure 6.33 *Significance of global developments*

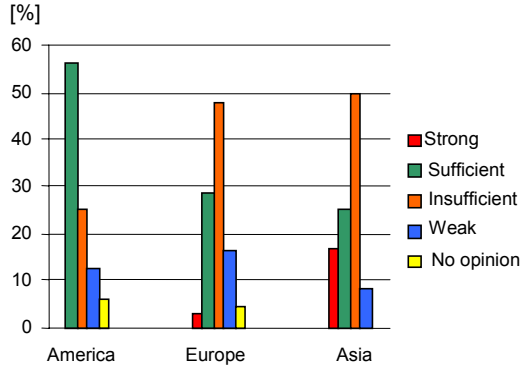

Figure 6.34 *The interaction between global developments*

6.15 Ranking of the factors

The two methods described in sections 5.4 and 5.5 are separately used to rank the factors. By ranking the factors from 'most Significant' to 'least Significant' and from 'best Status' to 'worst Status', more information is obtained from the returned questionnaires. In Table 6.1 the final ranks are presented for each region. In general the results of the two methods correspond to a large extent. The ranking presented in Table 6.1 is the result of the Friedman test. The Friedman test also calculates a number to indicate the significance of the calculated ranking. The result is somewhat more reliable than the medal classification result.

Table 6.1 *Ranking of the factors on Significance and Status for the regions, Friedman test*

	America		*Europe*		*Asia*		
	Significance rank	Status rank[1]	Significance rank	Status rank[1]	Significance rank[2]	rank[3]	Status rank[1]
Financing	1	13	3	8	4	5	5
Cost reduction	2	11	1	12	9	11	10
Spatial planning etc.	13	8	13	13	5	9	9
Other elements	8	10	14	7	11	13	12
Environmental merits	9	2	7	2	6	4	1
Technical reliability	3	1	2	1	8	10	2
Product diversity	12	9	11	6	10	12	7
Standardisation	6	6	8	11	7	9	6
Specialist knowledge	5	14	5	14	1	3	14
Image of PV	4	12	6	4	3	2	4
The role of RD&D	2	7	4	3	8	8	3
The PV network	10	4	9	9	8	1	13
Internationalisation	7	3	12	5	3	7	8
Global developments	11	5	10	10	2	6	11

1. The dark grey numbers in the column 'Status rank' represent the factors that need considerable improvement, the light grey numbers represent the factors that are relatively in a good position.
2. Ranking derived with the medal classification method, see Section 5.4
3. Ranking derived with the medal classification method, see Section 5.5

The figures in Table 6.1 lead to the conclusion that the respondents from the American region believe that money related factors (financing and cost reduction) are very Significant factors in achieving large-scale introduction of grid-connected PV systems. These factors are followed by the technical factors (the role of RD&D and the technical reliability). These four factors occupy the first three positions, 'cost reduction' and 'the role of RD&D' sharing the second place. The

answers from the European respondents correspond to a large extent with the results from the American respondents. The PV experts in Europe think that ‘cost reduction’ is the most Significant factor, ‘technical reliability’ the second and ‘financing’ the third. This leads to the conclusion that the respondents from America and Europe have the same opinion about the Significant factors.

The results from the Asian respondents are different compared to the other regions. Because the two methods give different results in many positions, it is hard to make any general conclusions. The result of the Friedman test is, however, not significant, see Table 6.2. The Significance ranking for Asia is therefore carried out with the medal classification method. This could be the reason for the different outcome. However, the result of the Friedman test also differs remarkably from the results for the American and European respondents. The most Significant factors according to the Asian PV experts are: 1 ‘specialist knowledge’, 2 ‘global develop-ments’ and 3 shared by ‘the image of PV’ and ‘internationalisation’.

The results of this study from the American respondents for the Status of the factors show that ‘technical reliability’ has the best Status, ‘environmental merits’ is second best and ‘internationalisation’ comes third. Linking these results with the results for Significance shows that the American respondents consider ‘technical reliability’ as very Significant but at the same time its Status is the best. This does not mean that ‘technical reliability’ needs no improvement: ‘technical reliability’ could be the least bad factor. The worst Status is for ‘specialist knowledge’, followed by ‘financing’. Linking these results with the results for Significance shows that the American respondents consider ‘financing’ to be very Significant, but its Status is very poor. This means that, according to the American respondents, ‘financing’ needs considerable improvement.

The Status ranking for the European respondents corresponds for the best and the second best position with the American results. The third position is for ‘the role of RD&D’. Linking these results with the results for Significance shows that the factor ‘technical reliability’ is highly Significant, with a good Status. Linking the worst Status factors with their Significant rank provides more information. Like for the American respondents, the worst Status is for ‘specialist knowledge’. The most interesting, however, is ‘cost reduction’. Its Status is bad and it is very Significant for achieving large-scale application of grid-connected PV systems. In other words, European respondents regard PV systems as too costly.

According to the Asian respondents the factors with the best Status are largely comparable with the European results. According to the Asian respondents ‘environmental merits’ has the best Status, ‘technical reliability’ is second and ‘the role of RD&D’ is third. The worst Status is for ‘specialist knowledge’, ‘the PV network’ and ‘other elements’. The worst Status for ‘specialist knowledge’ is remarkable in two respects. Firstly, all the respondents regard ‘specialist knowledge’ as the worst factor, which means that it should receive more attention. Secondly, the Asian respondents regard ‘specialist knowledge’ as the most Significant factor for achieving large-scale application of grid-connected PV systems, but their knowledge is very poor.

Ranking the factors according to the two methods is a first step. It is also important to know whether the ranking is significant or not. To discover if the ranking is significant the tested null hypothesis must be rejected. The test statistics are presented in Table 6.2.

All calculated values are significant except for the Significance ranking for Asia. Therefore, the null hypothesis indicating that there is no difference in Significance between the factors can be rejected; the calculated ranking is valid. The ranking for Asia in Table 6.2 is not based on the Friedman test but on the medal classification method. The result for Asia must therefore be interpreted carefully. The value of the chi-square statistic is 7.996, with a significance of 0.844. Therefore, the null hypothesis indicating that there is no difference in Significance between the factors must be accepted. The idea behind this statistic is that if there is no difference between groups, each subject's rankings would be random, and there would be no difference in the mean ranks across the variables. The different results for the ranks between the medal classification and the Friedman test accentuate the acceptance of the null hypothesis, see Table 6.1.

Table 6.2 *Test statistics on Significance and Status for the regions*

	America		*Europe*		*Asia*	
Test status for:	Significance	Status	Significance	for Status	Significance	for Status
N	16	16	68	66	11	11
Chi-Square	34.388	38.073	140.253	107.247	7.996	48.662
Df	13	13	13	13	13	13
Asymp. Sig	0.001	0	0	0	0.844	0

6.16 The most important factor for large-scale market introduction

It is possible to weigh the importance of the factors on the basis of the 'closed questions'. The essay question 'What do you consider the most important factor necessary to achieve a successful large-scale market introduction of grid-connected PV, and why?' explicitly asks for the most important factor. Analysis of the answers reveals that the financial factors are the most important. As much as 76 (67%) of the total 114 remarks[6] are related to financial factors, see Table 6.3. Comparing these results with the ranking calculated in Section 6.15 reveals that the answers from the American and European respondents resemble each other but the Asian answers differ. An explanation might be that the calculated ranking with the Friedman test is not significant for Asia.

Only 46 (40%) of the 114 remarks mention 'costs/price'. In addition to 'regulations' and 'subsidies' the 'German model'[7] is specifically mentioned. This is remarkable, because it is only one of the many possible financing schemes for PV. However, most of the respondents referring this 'German model' are German.

[6] The total number of remarks was taken. Some respondents did not answer question 16 at all, others have mentioned more than one factor. In this case, each remark counts as 1. Most respondents, however, only mention one factor.

[7] A payment of 0.99 DM for every kWh from PV, but there will be a rate reduction of 5% in each consecutive year. It is expected that with this instrument a total of 350 MW_p will be realised.

Table 6.3 *Response on the question about the most important factor*

	America	Europe	Asia	*Total*
COST RELATED REMARKS				
Cost/price	8	36	2	*46*
Regulations	1	8	3	*12*
Subsidies	2	8	2	*12*
German model	1	5	0	*6*
Total	*12*	*57*	*7*	*76*
NON-COST RELATED REMARKS				
Technical, RD&D	3	13	1	*17*
Marketing	1	3	2	*6*
Information, education & awareness	1	4	2	*7*
Other	2	6	0	*8*
Total	*7*	*26*	*5*	*38*
TOTAL	19	83	12	114

The responded suggestions can also be classified according to the parties that should undertake a suggested action. The parties mentioned by the respondents are the industry, the government, the consumers and a fourth category which contains all the other mentioned parties, see Table 6.4. The total number of actions mentioned is lower that the total number of suggestions made at this question. Not every respondent suggested a specific action, so that there is a difference between the totals of Tables 6.3 and 6.4. The European and Asian respondents believe that action should come from the government. These respondents mostly think of 'regulations combined with subsidies'. The American respondents do not have a specific party in mind.

Table 6.4 *Expects actions from specific parties*

	America	Europe	Asia	*Total*
Industry	2	5	1	*8*
Government	2	21	5	*28*
Consumers	0	2	1	*3*
None mentioned	9	27	1	*37*
Total	*13*	*55*	*8*	*76*

Figure 6.35 shows the results for the cost related factors. There is a close resemblance between America and Europe. Also, it is remarkable that the percentile of respondents in favour of the 'German system' is equal in America and Europe. The Mann-Whitney test has not been applied to these results. The visual difference in shape of the histograms for the American and European answers on the one hand and the Asian answers on the other hand is remarkable. The peaks in answers from the American and European respondents agree with the results in Section 6.15. The Asian answers, which has its peak at regulations, differs from the results in Section 6.15.

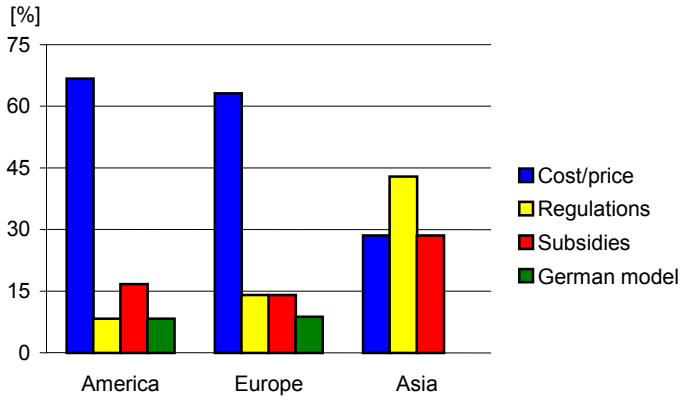

Figure 6.35 *Cost related remarks*

The non-cost related factors are shown in Figure 6.36. The high percentile for the 'technical/RD&D' factor in America and Europe is remarkable. This might be an indication that, according to the respondents the research infrastructure in America and Europe is less satisfactory than in Asia. The situation for 'information, education & awareness' and 'marketing' is the opposite. These factors are by the Asian respondents regarded as the most important while the American and European respondents rank these factors third and fourth. The reactions from the American and European respondents are surprising because PV is still a relatively new technology with a high-tech image. Another outcome was expected by the research team for a technology about which still a lot of confusion exists (especially about the difference between solar-thermal and PV) and most of the marketing still has to be undertaken.

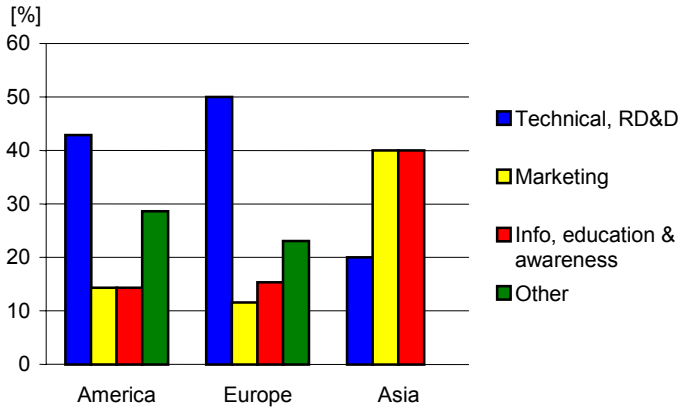

Figure 6.36 *Non-cost related remarks*

It is also remarkable that 39 out of 76 respondents (51%) are convinced that a certain party must undertake actions to achieve large-scale market introduction of grid-connected PV, see Table 6.4. Figure 6.37 shows which parties should take responsibility according to the respondents.

The difference between the American and Asian answers is remarkable. The American respondents do not think that any party has to take responsibility while the Asian respondents almost unanimously are of the opinion that some party should take the lead in large-scale PV introduction. The European respondents take a position between the American and the Asian respondents. The majority of the European and the Asian respondents think that the government should undertake the actions. Hardly any respondents mentioned important actions to be taken by individuals/consumers (only 3 out of 76 remarks). This is surprising in view of the recent successful PV introduction programs in Japan and Germany (the Japanese and German 100.000 roof programs) which were mainly undertaken by individual parties.

Some respondents mention that building integration and solar home systems are features, which bring PV much closer to the consumer than any other (renewable) electricity production system. This aspect should not be overlooked as an important issue to achieve large-scale market introduction of grid-connected PV.

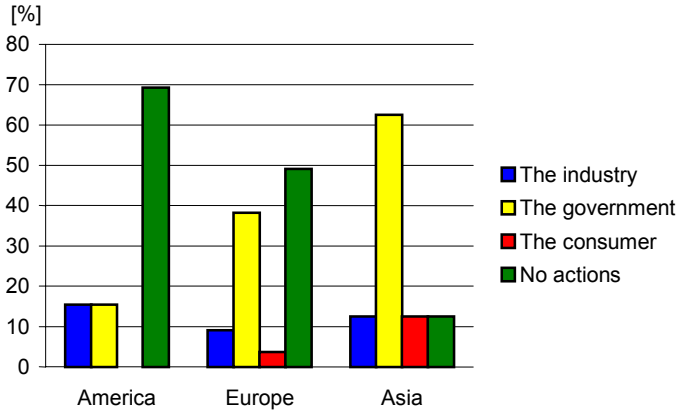

Figure 6.37 *Foreseen actions taken by a certain group*

6.17 The most impeding factor for large-scale market introduction

The European respondents on the question about the most impeding factor gave 60 answers. The most often mentioned items is 'cost'. The other four items take care of the other 50%. Seventeen American respondents answered this question. The American respondents mentioned 'cost' and 'market' aspects most frequently, 88% of the answers. The other 12% are categorised in the item 'other'. Ten Asian respondents answered the question about the most impeding factor. Again, the items most frequently mentioned were 'cost' and 'market' aspects, see Table 6.5. Asia is somewhat different from the other regions, 'cost' and 'market' having the same score. The main conclusion is that all respondents think that 'cost' is currently the most impeding factor.

Table 6.5 *Response on the most impeding factor*

	America	Europe	Asia	*Total*
Cost	8	29	4	*41*
Market	6	12	4	*22*
Government policy	0	9	1	*10*
Architecture	0	6	1	*7*
Other	3	4	0	*7*
Total	*17*	*60*	*10*	*87*

These results are different from the results calculated in Section 6.15. In that section the majority of the respondents regard 'specialists knowledge' as the most impeding factor. The American respondents have two total different top three lists. However, both top three rankings contain a financial factor like cost reduction or financing methods. The European respondents are more consisted in their opinion about the most impeding factors. Cost reduction as well as a governmental related factor appears in both top three rankings. The factors mentioned by the Asian respondents at question 17 result in a top three that is totally different from the top three in Section 6.15. General conclusions are therefore not possible. It is positive to notice that the most important factor for successful large-scale introduction of grid-connected PV systems in Section 6.16 is the same as the most impeding factor in Section 6.17: cost. Levelling this factor might be very helpful in speeding up the implementation of PV systems.

Cost

Most respondents consider the high cost of PV systems to be the major impediment for large-scale market introduction. About 50% of the European and the American respondents and 40% of the Asian respondents mention this issue. PV systems are deemed too expensive by at least a factor of 10. Generally, the respondents find that the sustainable character of PV does not offset this cost disadvantage.

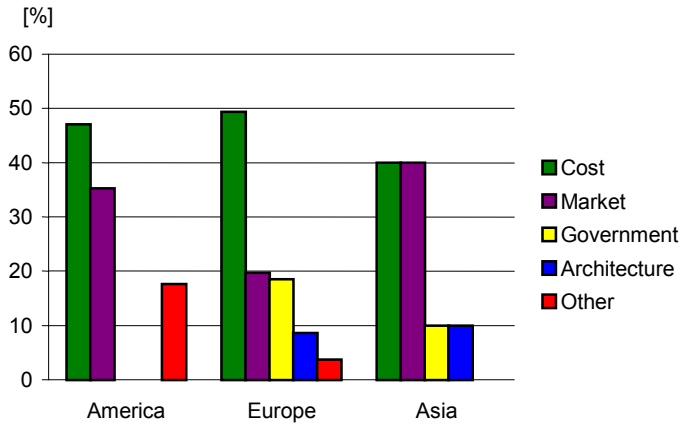

Figure 6.38 *Results from question 17 (% of respondents for each region)*

Market

The second important impediment to large-scale market introduction of PV is the lack of incentives in the market. Electric power companies do not stimulate a swift market introduction of PV. This is demonstrated by feed-in tariffs, which are too low. Also, local policies may hamper market introduction. Generally, there is lack of co-operation in the chain from producer to consumer. About 20% of the European, 35% of the American and 40% of the Asian respondents mention this issue.

Government policy

Insufficient financial incentives from the government are also mentioned as one of the reasons for the slow market introduction of PV. The cost of PV can only be reduced by large-scale investment. Governments should therefore give sufficient financial incentives in order to overcome the current lack of cost-effectiveness. However, the American respondents think that there is no role for the government, whereas 15% of the European respondents and 10% of the Asian respondents mention this issue.

Architecture

A number of respondents consider the integration of PV in buildings as a problem. Architects are not yet used to incorporating PV in their designs. Also the integration of PV systems in existing buildings deserves attention. However, the American respondents think that there is no role for architects, whereas 10% of the European and the Asian respondents mention this issue.

Others

Other impediments for market introduction of PV involve information, training, and standardisation. Customers do not generally understand the difference between solar thermal collectors and PV. Training of trades and sales persons is deemed important. Also the lack of national or international standards is considered a reason for the slow market introduction. Almost 18% of the American respondents and only 7% of the European have other ideas while no other ideas came from the Asian respondents.

6.18 Relation with other renewable energy options

Question 18 about the implications of other renewable energy options for large-scale market introduction of grid-connected PV was answered by 11 American, 44 European and 8 Asian respondents, which is 68.7%, 63.8% and 66.7% respectively of the total number of respondents.

According to the respondents the implications can be divided into 4 classes. Implications can be 'positive', 'more positive than negative', 'balance between positive and negative' or 'negative'. There are positive implications because

- other renewable energy options are or can be complementary to PV,
- a mixture of various renewables is needed to obtain a stable grid,
- it can raise the public awareness of the benefits of renewable energy sources.

The implications can be more positive than negative because

- the image has a greater influence than the price,
- every renewable energy source increases the interest in renewable energy options.

There is a balance between positive and negative because

- every renewable energy technology has its own market niche,
- different options exist but do not really compete with each other.

There are negative implications because

- other renewable energy options are much cheaper than PV.

The results for the question about the relation with other renewable energy options are summarised in Figure 6.39. The respondents generally feel positive about the relation with other renewable energy options, although about 11% of the respondents in Europe think that grid-connected PV systems will suffer from other energy options. 37% of the respondents in America chose 'positive' and 'more positive than negative'. 45% of the respondents in Europe chose 'positive' and 35% chose 'balance between positive and negative'. Finally, 50% of the Asian respondents chose 'balance between positive and negative' and 38% chose 'positive'. A general conclusion is that according to the respondents other renewable energy options are not considered to be a threat to PV.

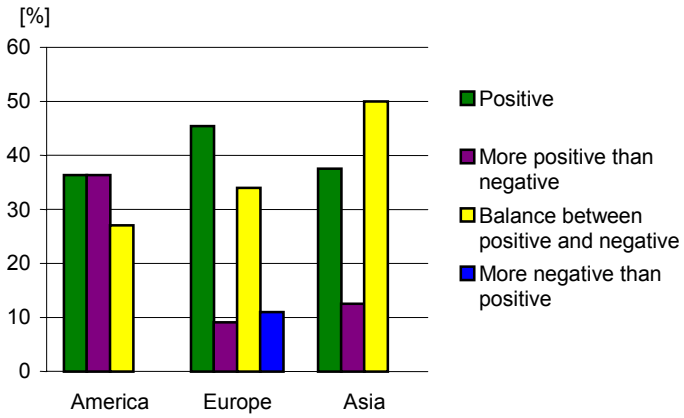

Figure 6.39 *Implications of other renewable energy options*

6.19 Remarks from the respondents

The final question of the questionnaire (see Annex B) offers the respondents the opportunity to indicate factors that they think have been omitted. Here the respondents could add one or more factors and explain briefly why these factors are important.

There were 5 American reactions, which is 31% of the total number of American respondents. They did not show a particular preference for one specific item. The items 'government policy', 'position of energy companies', 'image of PV' and 'developing countries' each scored 25%. There were 22 European reactions, which is 32% of the total number of European respondents. Four items scored 15%, i.e. 'marketing', 'government policy', 'position of energy companies' and 'others'. The other four items each scored 10%. There was only one Asian reaction (8% of the Asian respondents) mentioning the 'position of energy companies'. The score on this item is therefore 100%. Figure 6.40 shows the response to this question. The scale of the y-axis in Figure 6.40 is cut off at 40%, because otherwise the bars for America and Europe would have become very small.

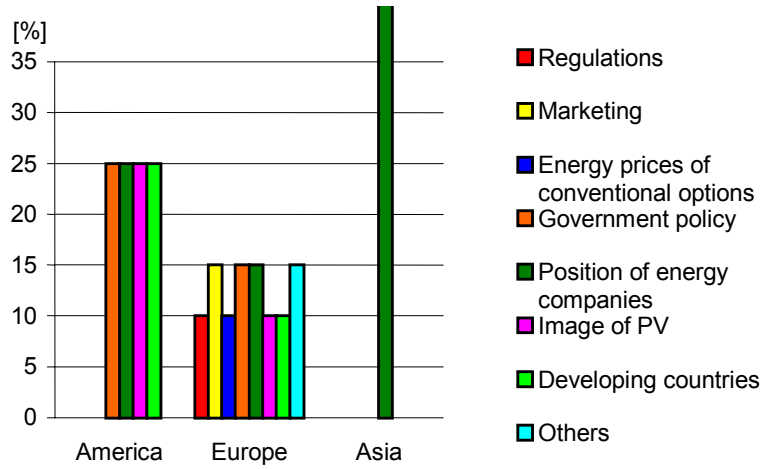

Figure 6.40 *Omitted factors (the value of the Asia bar is 100%)*

Regulations
A few respondents mentioned the importance of regulations. The government can make the use of PV systems compulsory for public buildings. However, regulations can also be an impediment to the development of a large-scale PV market. This can be observed in a number of countries where electricity companies have a quasi-monopoly position.

Marketing
According to the respondents' consumers seem to be an important market for PV systems. There are a number of arguments in favour of PV systems. If the pay back period of PV came down to a reasonable level, arguments such as 'image' and 'social status' would probably become less important than they are at the present time. The marketing strategy depends on the degree of maturation of PV systems (pay back period), the available incentives, and the extent of involvement of power companies.

Energy prices of conventional options
Several respondents stress the point that cost reduction is not the only option for expansion of the market for PV systems. An alternative option is to raise the price of conventional fuels, according to their environmental costs. This would have a beneficial effect on energy conservation and the use of renewable energy including PV systems.

Government policy
Most respondents are of the opinion that government policy is important for RD&D and market development. There is a marked difference in government support between the regions considered. The situation of PV in Germany is deemed very favourable. Subsidies are indispensable in the initial stages of demonstration and early market introduction. However, as soon as the market is gaining momentum - demonstration results are reported and used to improve the PV prod-

ucts; the number of projects is growing - it seems wise to develop other incentives, such as tax breaks and 'green' energy tariffs and certificates.

Position of energy companies

Some respondents wonder whether large energy companies engaged in PV (BP, Siemens, Shell, Agip, etc.) are really interested in a rapid development of PV. A number of respondents from Europe, America and Asia refer to problems related to the regulatory framework of the electricity sector. The problems mentioned include load acceptance and the possibility of feeding back into the grid at a reasonable rate. Liberalisation of energy markets could provide a solution to these problems.

Image of PV

According to the respondents PV should not be regarded solely from the perspective of the power generation cost. Indeed, the price of electricity from PV will remain relatively high for some time. However, most of the current methods for power generation cause CO_2 emission, and thus have hidden environmental costs. PV can be promoted as an environmentally benign method of power generation or perhaps as a luxury product (as long as PV remains expensive). Also, the government as part of the industrial policy can promote a large-scale market introduction of PV.

Developing countries

According to the respondents OECD countries focus their attention not only on grid-connected PV - largely for the household and building market - but also to certain extent on the large-scale application of PV in desert areas. In developing countries PV systems are normally not grid-connected. Stand-alone PV systems in developing countries seem to have a competitive edge over grid-connected PV in OECD countries. However, in America, Europe and Asia, PV systems can be promoted for other reasons than strict economic ones, such as its environmentally benign profile, 'social status', etc.

Others

The remaining comments from the respondents can be divided in short-term and long-term issues. A problem in the short term is the recycling of (parts of) PV systems. Some technologies are considered to be 'clean', others to be potentially problematic. Other short-term problems are education, communication and dissemination of information. It is uncertain whether the current distribution channels are sufficient for a large-scale market introduction. In the longer term, the interaction between large-scale PV and the grid, and options such as hydrogen storage and fuel cells, deserve attention.

6.20 Final remarks

- Although the Mann-Whitney test results sometimes seem to be in conflict with the histograms shown in Figure 6.1 to 6.40, the results are statistically indisputable. This means that the interpretation of the histograms by the human eye is different from SPSS calculation rules. If the data had been interpreted by eye, no objective conclusions would have been possible. The criterion of what is relevant, different or equal depends on several factors. Another project team would probably have used other criterion. We have chosen the Mann-Whitney test as a method, which operates with logical repeatable rules. An explanation for the conflict between Mann-Whitney results and the histogram shapes might be the different sample sizes of the three populations, see Table 4.2. The European population is 5.75 times larger than the Asian population and 4.3 times larger than the American is. By comparing a small population with a large population, differences might be overruled by the imbalance of the population size. The chance that a small population is similar to a part of a large population is considerable, see also Section 5 for more details about the Mann-Whitney test.
- Theoretically, in addition to differences or similarities between the regions, other comparisons could be made. It is possible, for example, to make comparisons according to type of

organisation. A distinction in type of organisation might reveal more differences or similarities than a distinction in regions does. We have decided not to make this comparison because the total number of respondents is insufficient. We defined 11 different types of organisations from the 97 questionnaires returned. On average this results in a response of less than 9 respondents per type of organisation. However, 1 respondent belongs to an environmental organisation and 38 belong to research institutes or universities. Any difference or similarity found between environmental organisations, research institutes or universities is statistically not significant.

- It was not possible to relate the differences and similarities found between the regions to the type of organisation to which the respondents belong. It was found that the respondents worked in at least 12 different types of organisations, unevenly distributed, and the resulting low statistical significance did not allow any conclusions to be drawn.

This study has identified differences and similarities between three major PV regions in the world. An explanation for these differences and similarities can not be deduced from this study. The questionnaire did not ask the respondents to explain their answers. Therefore, another survey may be necessary to explain the results of this study.

7. MAIN RESULTS AND CONCLUSIONS

In this section the conclusions from Section 6 are summarised. Each factor can be compared for 5 different situations. These 5 situations are:
1. the most important Significant factor,
2. the factor with the best Status,
3. the factor with the worst Status,
4. different shape for Significance,
5. different shape for Status.

The first three situations make it possible to rank the 14 factors from most to least important factor and from best to worst Status. The results and conclusions of ranking are summarised in paragraph 1. The results and conclusions regarding the different shape of Significance and Status are mentioned in paragraph 2 till 15. Six questions - about financing, other elements influencing market introduction, technical reliability, product diversity, image and internationalisation - can differ in a sixth situation. It is possible that the regions have different ideas, about which aspects are important for successful large-scale grid-connected PV systems, see annex B.

Significance or significance
At many places words are written with a capital although these words are not at the beginning of a sentence. This is done to distinguish the Significance of a factor from the significance of a SPSS test result. In consequence also the Status of a factor is written with a capital. Besides Status a factor the Pace of cost reduction, the Current situation of spatial planning & regulation & licensing, the number of initiatives and the Attention for image are written with a capital.

Ranking of the factors
The main results on the regional differences in and the ranking of the Significance of the critical success factors are given in Table 7.1.

Table 7.1 *Ranking of the factors according to Significance*

Rank	America	Europe	Asia
1	Financing	Cost reduction	Specialist knowledge
2	Cost reduction	Technical reliability	Global developments
3	RD&D	Financing	Image
4	Technical reliability	RD&D	Internationalisation
5	Image	Specialist knowledge	Financing
6	Specialist knowledge	Image	Spatial planning etc.
7	Standardisation	Environmental merits	Environmental merits
8	Internationalisation	Standardisation	Standardisation
9	Other elements	PV network	PV network
10	Environmental merits	Global developments	RD&D
11	PV network	Product diversity	Technical reliability
12	Global developments	Internationalisation	Cost reduction
13	Product diversity	Spatial planning etc.	Product diversity
14	Spatial planning etc.	Other elements	Other elements

Some interesting observations can be taken from this table:

- Financing and cost reduction are according to the respondents important factors in Europe and America. In Asia other factors are regarded as more important. The more detailed questions show that the 'sale of green power', 'subsidies' and 'tax measures' are regarded as the most important financing methods.
- Also RD&D and the technical reliability are Significant success factors according to American and European respondents. The Asian respondents regard this factor as less important.
- The opposite is true for global developments and internationalisation. The respondents from America and Europe regard these factors as a little less important, whereas in Asia these factors are seen as very important.
- The respondents from all the regions regard the PV network, standardisation, image and environmental merits as more or less important.
- Specialist knowledge is more or less important by the respondents in America and Europe. In Asia this is the most Significant factor.
- Interesting enough the American and European respondents consider spatial planning as the least Significant factor, whereas the Asia respondents find this factor rather important.
- Product diversity is not seen as an essential success factor in one of the regions.

The main conclusion is that the ranking of the main critical success factors on Significance shows no large differences between the American and European respondents. The answers from the American and European respondents show the same characteristics and large-scale market introduction of grid-connected PV may be influenced by the same success factors in order to achieve a successful introduction.

A ranking of the actual Status of the factors in Table 7.2 shows a different picture.

Table 7.2 *Ranking of the factors according to Status*

Rank	America	Europe	Asia
1	Technical reliability	Technical reliability	Environmental merits
2	Environmental merits	Environmental merits	Technical reliability
3	Internationalisation	RD&D	RD&D
4	PV network	Image	Image
5	Global developments	Internationalisation	Financing
6	Standardisation	Product diversity	Standardisation
7	RD&D	Other elements	Product diversity
8	Spatial planning etc.	Financing	Internationalisation
9	Product diversity	PV network	Spatial planning etc.
10	Other elements	Global developments	Cost reduction
11	Cost reduction	Standardisation	Global developments
12	Image	Cost reduction	Other elements
13	Financing	Spatial planning etc.	PV network
14	Specialist knowledge	Specialist knowledge	Specialist knowledge

Some interesting observations can be taken from Table 7.2.

- All respondents are convinced that the technical reliability and the environmental merits of PV systems are well developed.
- The Status of RD&D, image and financing are regarded rather good by the European and Asian respondents. The American respondents see the Status of these factors as rather poor developed.
- Standardisation and product diversity are regarded more or less well developed by all the respondents.
- The Status of the factors internationalisation, global developments and the PV network are regarded as well developed in America, a little less in Europe and less developed in Asia.
- Cost reduction is rather poor developed in all regions

- All the respondents regard the Status of specialist knowledge as poor developed in their region.

The main conclusion is that the three regions differ in the ranking of the actual Status of the factors. A comparison of the rankings between America and Asia show the largest differences, whereas Europe is taking an intermediary position. An interesting observation is that the Status of factors like internationalisation, global developments and the PV network is regarded more positive in America, whereas Asia and Europe are more positive about the factors RD&D, image and financing.

The results of this study can be used in many ways for instance in policy making and strategy formulating per region in order to reach large-scale market introduction of grid-connected PV. Although a lot information is already available for these fields the results of this study might reveal new insights. However, it goes beyond the scope of this study to advice decision-makers directly. By looking into the Significance of a specific success factor on the one hand and the actual Status of the same factor on the other hand, a decision-maker may come to his or her own conclusions. The conclusion might be that the factor needs to be addressed in policy making or a strategy formulation or that it can be neglected. Although it is very tempting to start working on, this explicitly goes beyond the scope of this study and needs to be done for a certain region and from a certain perspective like that of policy making or commercial strategy formulation. Therefore, recommendations on policy or strategy are not in this report.

Financing
There are no statistically significant differences in respondents' opinion between the regions with respect to the Significance of financing. According to the respondents the Status of financing in Europe differs from the Status in America and Asia. The American and Asian respondents have statistically the same Status.

In general all the regions respondents have the same ideas about the different financing methods. The 'sale of green power', 'subsidies' and 'tax measures' are considered as the most important financing methods. Other financing methods suggested by European respondents are 'tax measures for a period of 10 years' and 'more programmes like the 100.000 roof programme in Germany'. From Asia comes the suggestion for 'green energy credits' to be given to the manufacturers of PV systems in order to achieve a price reduction. An American suggestion is more 'rate-based incentives'.

Cost reduction
The respondents regard the Significance of cost reduction in Asia different from the Significance in America and Europe. Generally, the respondents in Asia regard cost reduction to be less Significant than the American and European respondents. The American and European respondents have the same ideas about the Significance of cost reduction. They both regard it as highly Significant. All the three regions are of the opinion that the Pace of cost reduction is not fast enough.

Spatial planning
According to the Mann-Whitney test no differences occur in the Significance as well as in the Status of spatial planning, regulation and licensing in the three regions. However, the Asian respondents regard the Significance of spatial planning, regulation and licensing as highly important while the American and European respondents consider this factor of average importance.

Other elements influencing market introduction
There is no difference between the regions' respondents in the Significance of other elements influencing market introduction. Statistically there are also no differences in the Number of initiatives taken by the three regions.

The respondents in Europe and Asia have different ideas about which other elements are important for market introduction. America is not significantly different from Asia or Europe, which means that the American respondents mention the same elements as mentioned by the other respondents. Asian respondents stress the importance of 'pioneering activities' while European respondents emphasise 'initiatives by social organisations' and 'autonomous PV'. The American respondents also stress the importance of 'pioneering activities'. Other options mentioned by European respondents are 'integration of PV in buildings' and 'initiatives by local utilities'. Asian respondents also mentioned 'public education' and 'government sponsored schemes'.

Environmental merits

The Significance of environmental merits is statistically different between the American and European respondents. The European respondents have a more explicit opinion about the environmental merits rating them as 'high'. The American and Asian respondents vary between 'high' and 'average'. The Status of environmental merits does not differ statistically between the respondents from the three regions. Europe and Asia tend more toward 'sufficient' while America tends toward 'insufficient'.

Technical reliability

There is a difference in Significance of technical reliability between Asia and the situation in America and Europe. The Asian respondents regard technical reliability as less Significant than the other respondents do. There is no statistical difference in the Status of the technical reliability between the three regions, although the European respondents tend explicitly toward 'sufficient' and the other two respondents do not.

In general, all the respondents have the same ideas about which technical reliability aspects are the most important. All the regions regard 'certification and standardisation' as the most important aspect. The American suggestions can be summarised as 'more and better tests', 'specific tests for input and output devices' and 'integrated systems tests'. The European respondents make almost the same suggestions with the addition of 'installer training' and 'maintenance contracts'. The Asian respondents suggest more reliability in 'volume production' and 'training in the PV power trade'.

Product diversity

According to the respondents there is no difference in the Significance of product diversity between the three regions. Statistically there are also no differences in the Status of product diversity. All the respondents consider mounting as the most important aspect of product diversity.

In addition the American respondents stresses the importance of 'colour and dimension' of PV systems for building integration. Some more suggestions are made by the European respondents such as 'integration with small systems (cordless)', 'packaging with other roof components' and the 'shape (form and application) of the systems'. On the other hand, there are respondents who believe that as long as the cost is high, product diversity cannot be an issue. One respondent in Asia considers the 'ease of installation' an important product diversity aspect.

Standardisation

The respondents from the three regions consider standardisation to be a highly important factor. There is a statistical difference between the Status of standardisation in Europe and Asia. The Asian respondents are more optimistic about the Status of standardisation. Generally, the American and European respondents regard the Status of standardisation as 'insufficient' while the Asian respondents are somewhat more optimistic about the Status.

Specialist knowledge
No differences occur in the Significance of specialist knowledge between the three regions. Although the American and European respondents regard the Status of specialist knowledge is slightly better than the Asian respondents, only Europe and Asia differ significantly. It is remarkable that all the respondents consider specialist knowledge as the factor that has the worst Status. This is stressed by the fact that the Asian respondents regard the technical knowledge of specialists as the most Significant factor for reaching large-scale grid-connected PV systems.

Image
There is no difference in the Significance of image between the three regions because all regions rate the Significance of image as 'high'. The American respondents rate the attention given to image higher than the European and Asian respondents do.

There is no significant difference in preference of image aspects between the regions. All the regions regard 'environment' as the most important aspect of image. According to some American respondents 'aesthetics' and 'competitiveness with utility' are also important aspects of image. The European respondents stress the importance of 'reliability as a building element'. An Asian respondent regards 'the socially right thing to do' also as an image aspect. Remarkable is the suggestion of a European respondent that the importance of image decreases as the cost comes down.

The role of RD&D
Statistically no differences occur in the Significance of RD&D between the regions. However, the American and European respondents regard RD&D as highly important while the Asian respondents score 50% high and 50% average. The Status of RD&D is significantly different in each region. Generally, American respondents regard the Status of RD&D as 'insufficient', the European respondents as 'sufficient to insufficient' and the Asian respondents as 'sufficient'.

Technical/commercial network
Generally, the Significance of the technical/commercial network is 'high' to 'average' in all the regions. There is a statistical difference in the Status of the technical/commercial network between the Asian and American respondents. The Status of the technical/commercial network is regarded as 'sufficient' by the American respondents, while the European respondents regards the Status 'insufficient' and the Asian respondents 'insufficient' to 'poor'.

Internationalisation
No statistical difference is found for the Significance and Status of internationalisation between the three regions interviewed experts. All the regions consider internationalisation to be highly Significant. The Status of internationalisation is in all regions considered to be 'sufficient' to 'insufficient'.

There is a statistical difference between Europe and Asia regarding which forms of internationalisation are important. The Asian respondents prefer 'development aid' while the European respondents have no specific preference. From America comes the suggestion for 'more standardisation in the field of internationalisation. The European respondents would like to see an 'open European PV market' and the 'regulation of grid-connection must be harmonised'. Asia would like to see more attention given to 'the exchange of information and experience'. In addition to these suggestions a respondent remarks that development aid should be given to a few specific countries. Another respondent thinks that internationalisation is no longer an issue because all the major PV companies are multinationals.

Global development
There are no statistical differences in Significance of global developments between the regions, the experts all regard global developments as highly important. No statistical differences are

found in the Interaction of global developments between the respondents' answers. However, the American respondents have the opinion that there is a strong Interaction between global developments, while the European and Asian respondents regard the Interaction as 'sufficient'.

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ANNEX A LIST OF PERSONS THAT HAVE BEEN INTERVIEWED

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ANNEX B QUESTIONNAIRE AND COVERING LETTERS

Questionnaire on the critical success factors for PV

Opportunities and threats for large-scale grid-connected PV introduction

The aim of this survey is to make an inventory of the most Significant factors to turn grid-connected PV into a mature market product. In addition, we wish to make an international comparison of the Significance and Status of these factors. We are therefore conducting this survey among 450 respondents all over the world that are professionally involved with PV.
If you would like to receive a copy of the report of this study, please complete the separately attached form and return it to us together with the questionnaire.

Factors for consideration

- financing
- cost of PV
- spatial planning, permits and licences
- activities in other sectors influencing market introduction
- environmental merit
- technical reliability
- product diversity
- standardisation
- specialist knowledge of PV systems and installation
- image of PV
- RD&D
- technical/commercial network
- internationalisation
- global developments in other PV sectors

The first question about your country, company and work will remain confidential. The answers will enable us to establish a possible relationship between answers and line of work and to identify regional differences. The survey will take approximately twenty minutes to complete.

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1. Personal background

Your PV knowledge relates to a particular country or a specific part of the world. This is not necessarily the country where you were born, or where you currently live and work. This aspect is important for enabling us to distinguish between the various regions, for example, USA, Europe and Japan.

1a. Please identify the country or region for which your PV expertise is greatest. Your answers in this questionnaire should apply to this country or region.

_____

1b. In which type of organisation are you employed?

- ☐ Architectural firm
- ☐ Bank
- ☐ Consultancy firm
- ☐ Energy company
- ☐ Environmental organisation
- ☐ Government
- ☐ Project development
- ☐ PV sales and distribution
- ☐ PV installation
- ☐ PV production or assembly
- ☐ Research institute/university
- ☐ _____

1c. What is your main activity in the field of PV?

_____

1d. What is your function within the organisation? (answer not obligatory)

Function:_____

---

2. The financing of a grid-connected PV system

Lease constructions, pay-back tariffs, sale of 'green' power (i.e. solar power), subsidies and tax measures are aspects to be considered in the financing of grid-connected PV systems. They can influence the expected cost or revenue of PV systems.

2a. In your opinion, how Significant is adequate financing of PV in achieving large-scale application, and how, according to you, are the current regulations and arrangements for financing in your country?

Significance
- ○ High
- ○ Average
- ○ Low
- ○ No opinion

Status of financing
- ○ Good
- ○ Sufficient
- ○ Insufficient
- ○ Poor
- ○ No opinion

2b. Which financing method or contribution in financing, according to you, is the most effective for the introduction of PV? (More than one answer possible.)

- ☐ Lease constructions
- ☐ Pay back tariffs
- ☐ Sale of 'green' power
- ☐ Subsidies
- ☐ Tax measures
- ☐ _____

---

3. Cost reduction of PV

The cost of PV can be reduced by technological improvements and innovations, learning and scaling effects in the production and the installation, standardisation, etc.

3a. In your opinion, how important is cost reduction in PV necessary to achieve large-scale application, and do you think that cost reduction is currently taking place at an acceptable pace?

Significance	Pace of reduction
○ High	○ Fast
○ Average	○ Sufficiently fast
○ Low	○ Not fast enough
○ No opinion	○ Slow
	○ No opinion

---

4. The role of spatial planning and regulation and licensing

The orientation and the position of a PV system are contributory factors to the energy yield of the system and therefore to its economic feasibility. Favourable positioning of PV systems (in new buildings) also depends on spatial planning, regulation, and licensing. Think of 'sun friendly' allotment and building, and of 'right to sun').

4a. What, in your opinion, is the Significance of spatial planning and regulation and of licensing for achieving large-scale application, and how, according to you, is the current situation?

Significance	Current situation
○ High	○ Favourable
○ Average	○ Favourable enough
○ Low	○ Not favourable enough
○ No opinion	○ Unfavourable
	○ No opinion

---

5. Other elements influencing market introduction

Application of stand-alone PV systems, activities in niche markets (for example, PV in consumer electronics), initiatives by NGOs, non-governmental organisations, such as Greenpeace and WWF, pioneering activities in grid-connected PV systems ('early adopters' and new application areas), etc., can stimulate directly or indirectly the large-scale introduction of grid-connected PV.

5a. What, in your opinion, is the Significance of other activities influencing market introduction for achieving large-scale grid-connected PV implementation, and do you think that sufficient initiatives are currently being developed in your country?

Significance	Number of initiatives
○ High	○ Many
○ Average	○ Sufficient
○ Low	○ Insufficient
○ No opinion	○ Few
	○ No opinion

5b. Which of these activities, according to you, is the most important? (More than one answer possible.)

- ☐ Autonomous PV systems
- ☐ Initiatives by social organisations (for example Greenpeace's Solaris project)
- ☐ Niche markets (for example, consumer electronics)
- ☐ Pioneering activities
- ☐ _____

---

6. The environmental merits of PV

PV is generally considered an environmentally friendly technology (clean, silent). In fact, the environmental merits of PV are determined by aspects such as the energy pay-back time and the (re)use of scarce and/or toxic (raw) materials.

6a. What, in your opinion, is the Significance of the environmental merits for achieving large-scale application, and what is the current status?

Significance	Status of environmental merits
○ High	○ Good
○ Average	○ Sufficient
○ Low	○ Insufficient
○ No opinion	○ Poor
	○ No opinion

---

7. Technical reliability

Technical reliability can be important for large-scale application of PV systems. The reliability of a system is determined by aspects such as the quality and the compatibility of the components and the quality of the installation. Certification, standardisation (of the production, the design, the components and/or the system), guarantees and commissioning tests can play a role in improving and ensuring the technical reliability.

7a. In your opinion, how important is the technical reliability of PV systems in achieving large-scale application, and how is the current status?

Significance	Reliability is
○ High	○ Good
○ Average	○ Sufficient
○ Low	○ Insufficient
○ No opinion	○ Poor
	○ No opinion

7b. Which aspect, in your opinion, is the most important to ensure technical reliability? (More than one answer possible)

☐ Certification and standardisation
☐ Commissioning tests
☐ Guarantees
☐ _____

---

8. Product diversity

For a large-scale introduction of grid-connected PV systems, various types of products should be available such as, for example, rigid or flexible modules, roof filling or small 'plug and play' systems. In addition, variations in appearance or dimension might be desirable. Also, different mounting systems (add-on, integrated, or self-supporting constructions) might be desired.

8a. What, in your opinion, is the Significance of product diversity in order to achieve large-scale application, and what, in your opinion, is the present situation?

Significance	Product diversity is
○ High	○ Good
○ Average	○ Sufficient
○ Low	○ Insufficient
○ No opinion	○ Poor
	○ No opinion

8b. For which aspect, according to you, is diversity the most important?

- ☐ Power (Wp)
- ☐ Colour
- ☐ Dimension (length/width)
- ☐ Electrical grid connection (for example, in meter box or by wall socket)
- ☐ Mounting systems to/on existing and new buildings and other objects
- ☐ _____

---

9. Standardisation for implementation of PV systems

Standardisation may be necessary to facilitate the work of system designers, architects and installers. It can also lead to quality improvement and cost reduction.

9a. How Significant, according to you, is standardisation for the implementation of PV systems necessary in order to achieve large-scale application and what is the current status of standardisation?

Significance	Status is
○ High	○ Good
○ Average	○ Sufficient
○ Low	○ Insufficient
○ No opinion	○ Poor
	○ No opinion

---

10. Specialist knowledge of PV systems and PV installation

It seems that few potential operating companies, installers, architects and project developers have sufficient specialist knowledge of PV systems. A better understanding of PV technology could stimulate this group to include more PV in their product or service packages.

10a. What, in your opinion, is the Significance of knowledge of PV among operating companies, installers, architects and project developers, in order to achieve large-scale application, and how would you describe the present level of knowledge among this group?

Significance	Knowledge is
○ High	○ Good
○ Average	○ Sufficient
○ Low	○ Insufficient
○ No opinion	○ Poor
	○ No opinion

---

11. Image of PV for grid-connected applications

In addition to material factors (yield, operating life, cost), immaterial factors such as the image of PV also play a role. The image of PV could reflect, for example, environmental awareness, independence (self-sufficient in terms of energy), high-tech, luxury, trend setting.

11a. How Significant, according to you, is the image of PV necessary to achieve large-scale application, and does it receive enough attention?

Significance	Attention is
○ High	○ Good
○ Average	○ Sufficient
○ Low	○ Insufficient
○ No opinion	○ Poor
	○ No opinion

11b. Which aspect of the image can improve the large-scale introduction of PV? (More than one answer possible.)

- ☐ Environmental awareness
- ☐ Independence
- ☐ High-tech
- ☐ Luxury
- ☐ Trend setting
- ☐ _____

---

12. The role of RD&D in the PV sector

Research, Development and Demonstration (RD&D) is one of the factors considered important in preparing PV for the market. This applies to the entire route, from fundamental research to field experiments and demonstration projects.

12a. What, in your opinion, is the Significance of RD&D in the PV sector in achieving large-scale application, and what is the current status?

Significance	RD&D is
○ High	○ Good
○ Average	○ Sufficient
○ Low	○ Insufficient
○ No opinion	○ Poor
	○ No opinion

---

13. Technical/commercial network in the PV sector

For a large-scale implementation of PV systems the 'distribution column' from producer to end user and the interaction between institutions, companies and individuals active in R&D, production, sale, installation, exploitation, licensing, publicity and promotion, financing and legislation is important. If these groups keep each other informed of their efforts, difficulties and progress, PV will become more successful than when each group operates individually.

13a. What, in your opinion, is the Significance of an adequate technical/commercial network in achieving large-scale application, and what is the current status?

Significance	The network is
○ High	○ Good
○ Average	○ Sufficient
○ Low	○ Insufficient
○ No opinion	○ Poor
	○ No opinion

---

14. Internationalisation

Internationalisation can take place, for example, by collaboration in R&D, by the transfer of PV production or assembly to low-income countries or by trade in PV-generated power. Regional collaboration, for example, within the European Union, is also considered a form of international collaboration in this survey.

14a. What, in your opinion, is the Significance of international collaboration in achieving large-scale application, and what is the current status?

Significance	International co-operation is
○ High	○ Good
○ Average	○ Sufficient
○ Low	○ Insufficient
○ No opinion	○ Poor
	○ No opinion

14b. Which of these forms of international collaboration should be given priority? (More than one answer possible.)

- ☐ Development aid
- ☐ Distribution and trade in PV-generated power
- ☐ Harmonisation of government policy for PV
- ☐ Transfer of production to low-income countries
- ☐ R&D
- ☐ Regional introduction programmes (e.g. EU)
- ☐ _____

---

15. Global developments in the PV sector

In addition to the market for grid-connected PV in the industrialised countries, there are other markets for PV. Examples are autonomous systems (Solar Home Systems) in developing countries, PV for consumer electronics and grid-connected PV in non-industrialised countries. These markets could stimulate the development of grid-connected PV, for example, through learning effects and 'economy of volume'

15a. What, in your opinion, is the Significance of the other global developments in the PV sector, in achieving large-scale application of grid-connected PV, and how is the interaction between grid-connected PV in the industrialised countries and the other global developments?

Significance
- ○ High
- ○ Average
- ○ Low
- ○ No opinion

Interaction is
- ○ Strong
- ○ Sufficient
- ○ Insufficient
- ○ Weak
- ○ No opinion

---

16. What do you consider the most important factor necessary to achieve a successful large-scale market introduction of grid-connected PV, and why?

_____

_____

_____

_____

_____

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17. What, in your opinion, is currently the most important factor impeding the large-scale market introduction of grid-connected PV, and why?

_____

_____

_____

_____

_____

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18. *What, according to you, are the implications (positive and/or negative) of other renewable energy options for a large-scale market introduction of grid-connected PV, and why?*

_____

_____

_____

_____

_____

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19. *If you feel that one or more factors have been omitted, would you please indicate them below and explain briefly why you find them important.*

_____

_____

_____

_____

_____

WE APPRECIATE YOUR CO-OPERATION

If you would like to receive the report of this study, please complete the box below.

Name	
Organisation	
Address	
Postal code	
City	
Country	

Letter sent with the questionnaire

Date:	8 November 1999	Tel direct:	(+31) 224 56 41 34
Your ref:		Fax direct:	(+31) 224 56 33 38
Our ref:		E-mail:	t.delange@ecn.nl

Subject: Survey on the critical success factors for PV

Dear Sir or Madam,

The Netherlands Energy Research Foundation ECN carries out an extensive R&D programme on photovoltaic solar energy (PV) on behalf of commercial companies and governmental organisations. More than 75 scientists at ECN perform research on topics ranging from cells and modules, system technology and building integration to the technical and non-technical aspects of PV implementation.

In recent years, many studies have been conducted on PV implementation. These studies, which mainly focus on a specific country, thoroughly analyse the non-technical aspects which play an important, or even a decisive role in the process of large-scale market introduction of grid-connected photovoltaic systems. We have examined the results of these various studies and have compiled valuable information. Some questions, however, still remain unanswered, for example:

- Are the non-technical aspects of PV implementation of equal importance in all countries?
- What priority can be given or ranking can be made, when comparing the various non-technical aspects in the different countries worldwide?
- What is the present status of the various non-technical aspects in the different countries worldwide?

The answers will give us more insight into the possible development routes which grid-connected photovoltaic systems might follow in different regions of the world.

As a research method we have chosen to survey the opinion of PV experts and persons involved in the implementation of PV. Our aim is, firstly, to establish the factors which are considered important to turn grid-connected PV into a mature market product and, secondly, to carry out an international comparison between the Significance and the status of these factors. We have therefore sent this questionnaire to you and to about 500 other persons all over the world. This inquiry is being conducted to identify the internal and external factors which are of vital importance to a successful large-scale market introduction of grid-connected PV systems.

We kindly ask you to participate in our survey by completing the enclosed questionnaire and returning it by mail or by fax (see fax number above) before 29 November 1999. Alternatively, you can complete the electronic version on our website (www.ecn.nl/unit_bs/survey). We will be pleased to send you the report of this survey so that you may also benefit from the results. If you would like to receive a copy, please complete the attached form.

Ir. Theo de Lange in our Policy Studies Department is the contact person for this survey. He can be reached at the numbers in the header of this letter.

I would like to thank you in advance for your co-operation.

Yours faithfully,
Professor Dr W.C. Sinke
ECN Solar & Wind Energy
Manager Solar Energy

Reminder letter

Date: 3 December 1999
Your ref.:
Our ref.:

Tel: (+31) 224 56 41 34
Fax: (+31) 224 56 33 38
E-mail: t.delange@ecn.nl

Subject: Reminder for the survey on the critical success factors for PV

Dear Sir, dear Madam,

Early November 1999 we sent you a letter in which we invited you to participate in a survey on the critical success factors for a large scale development of grid connected PV systems. We sent the questionnaire to you and about 500 other persons all over the world. In the letter, we asked you, as a PV expert or person involved in the implementation of PV, to return the questionnaire before 29 November 1999.

We already received a considerable number of questionnaires from all over the world in order to be able to conduct an analysis, but of course, more reactions are welcome. The more reactions we receive the more reliable the results of our analysis will be.

Therefore, we would like to repeat our invitation to participate in this survey. The questionnaire can be returned until the end of 1999 by mail, by fax (see fax number above) or by completing the electronic version on our website (www.ecn.nl/unit_bs/survey). Questionnaires received after 31/12/1999 cannot be included in our analysis. In December 1999, we start with the translation of the returned questionnaires from paper to electronic data for statistical analysis. Therefore, the first results will be available by January 2000. We will be pleased to send you the report of this survey so that you may also benefit from the results. If you would like to receive a copy, please complete the form that is attached to the questionnaire.

Ir. Theo de Lange of our Policy Studies Department is the contact person for this survey. He can be reached at the numbers in the header of this letter.

In case you already sent us the questionnaire, please disregard this letter.

I would like to thank you in advance for your kind co-operation.

Yours faithfully,

Professor Dr W.C. Sinke
Manager Solar Energy
ECN Solar & Wind Energy

ANNEX C LIST WITH SELECTED PV-EXPERTS

Table C.1 *List of PV-experts who have returned the questionnaire and indicated that they would like to receive a report of this study*

NAME	*ORGANISATION NAME*	*SUBNAME*	*GROUP NAME*	*CITY*	*COUNTRY*
A. Cuevas	Australian National University (ANU)	Department of Engineering	FEIT	Canberra	Australia
N. Gordon	Energy Australia			Sydney, NSW	Australia
D. Morphett	Pacific Power			Sydney	Australia
Dr. M. Watt	University of New South Wales (UNSW)	School of Electrical Engineering	Centre for PV Engineering	Mudgee	Australia
R. Haas	Vienna University of Technology	Institute of Energy Economics		Vienna	Austria
M.Th. Langlois d'Estaintot	European Commission (CEC)	Directorate General 12 (DG XII): Science, Research and Development		Brussels	Belgium
J. Nijs	Interuniversitair Mikro-Elektronica Centrum VZW (IMEC)		Solar Cells Materials and Packaging Department	Heverlee (Leuven)	Belgium
C. Nyman	Soleco Ltd.	Solar Energy Consult		Borgå	Finland
J.C. Muller	Centre National de la Recherche Scientifique (CNRS)	Laboratory of physics and applications of semiconductors (Laboratoire PHASE)		Strasbourg Cedex 2	France
Prof. A. Laugier	Institut National des Sciences Appliquées de Lyon (INSA)	Laboratoire de Physique de la Matière (LPM), UMR CNRS 5511		Villeurbanne Cedex	France
Dr. D. Bonnet	Angewandte Neue Technologien GmbH (ANTEC)		Solar Energy	Kelkheim	Germany
Prof.dr. P. Woditsch	Bayer AG	Central Research	Inorganic industrial products	Krefeld	Germany
R. Hanitsch	Berlin University of Technology	Institute of Electrical Power Engineering Renewable Energy Section Sec. EM4		Berlin	Germany
Ir. F.P.H. Wouters	Ecofys Energieberatung und Handelsgesellschaft mbH			Köln	Germany
P. Koltay	Fraunhofer Institute for Solar Energy Systems (ISE)	Solar Cells - Materials and Technology		Freiburg	Germany
Prof.dr. W. Wettling	Fraunhofer Institute for Solar Energy Systems (ISE)	Solar Cells - Materials and Technology		Freiburg	Germany
Dr. A. Jäger-Waldau	Hahn-Meitner-Institut GmbH		Department FH (Het. Materials Systems) /SE2 (Solar Energy)	Berlin (Wannsee)	Germany
R. Könenkamp	Hahn-Meitner-Institut GmbH		Department FH (Het. Materials Systems) /SE2 (Solar Energy)	Berlin (Wannsee)	Germany
Mrs. U. Jahn	Institut für Solarenergieforschung Hameln/Emmerthal (ISFH) GmbH			Erlangen	Germany
D. Tegtmeyer	Institut für Solarenergieforschung Hameln/Emmerthal (ISFH) GmbH	Photovoltaics		Emmerthal	Germany

Table C.2 *List of PV-experts who have returned the questionnaire and indicated that they would like to receive a report of this study*

NAME	*ORGANISATION NAME*	*SUBNAME*	*GROUP NAME*	*CITY*	*COUNTRY*
E. Pschorr-Schoberer	Ludwig-Bölkow-Systemtechnik GmbH			Ottobrunn	Germany
Dr. K. Wambach	Pilkington Solar International GmbH	Gelsenkirchen		Gelsenkirchen	Germany
Dr. H-C. Funke	RWE Energie AG	Regeneratieve Stromerzeugung (KR)	Division Marketing	Essen	Germany
Dipl.-Ing. W. Hoppe	RWE Energie AG	Regeneratieve Stromerzeugung (KR), SSW		Andernach	Germany
Dr. H. Nussbaumer	Sunways AG			Konstanz	Germany
Dr. W. Wiesner	TÜV Rheinland	Sicherheit und Umweltschutz GmbH		Cologne	Germany
D. Wolters	Wuppertal Institut for Climate, Energy, Environment			Wuppertal	Germany
H. Gabler	Zentrum für Sonnenenergie- und Wasserstoff-Forschung (ZSW)	Baden-Württemberg	Geschäftsbereich 1 - Photovoltaik	Stuttgart	Germany
Dr. A. Zachariou	Center for Renewable Energy Sources	Department of Photovoltaic Systems		Pikermi	Greece
Dott.Ing. P. Menna	ENEA	Centro Ricerche Portici, Località Granatello		Portici (Napoli)	Italy
S. Castello	ENEA	Department of Energy, Centro Ricerche Casaccia		S. Maria di Galeria-Roma	Italy
R. Vigotti	ENEL	R&D Department		Cologno Monzese (MI)	Italy
F. Paletta	ENEL - CISE spa - Segrate	PV Laboratory		Segrate (Milan)	Italy
Dr. J. Sachau	European Commission (EC), Joint Research Centre (JRC)	Institut for Advanced Materials (IAM) - Energy Systems Testing Unit (EST)	European Solar Test Installation (ESTI)	Ispra (VA)	Italy
F. Ferrazza	Eurosolare S.p.A.			Nettuno (Roma)	Italy
S. Pizzini	University of Milan	Department of Materials Science		Milan	Italy
T. Kasahara	MSK Corporation			Tokyo	Japan
Prof. T. Saitoh	Tokyo University of Agriculture and Technology	Faculty of Technology	Department of Electrical & Electronics Engineering	Tokyo	Japan
Dr. G.J. Jongerden	AKZO NOBEL		Central Research	Arnhem	Netherlands
E. Middelman	AKZO NOBEL		Central Research	Arnhem	Netherlands
L.A. Stigter	AKZO NOBEL		Central Research	Arnhem	Netherlands
Dhr.Ir. E.G. Israëls	Boom Milieukundig Onderzoeks & Ontwerp Buro			Delft	Netherlands
Ir. J.J. Schermer	Catholic University of Nijmegen	Faculty of Natural Sciences	Research Institute for Materials	Nijmegen	Netherlands
Drs. H.C. Schneider	CEA Communicatie en Adviesbureau			Rotterdam	Netherlands
J.H.J. Roos	Centre for Energy Conservation			Delft	Netherlands
M. Kleintunte	Croon Duurzaam			Rotterdam	Netherlands

Table C.3 *List of PV-experts who have returned the questionnaire and indicated that they would like to receive a report of this study*

NAME	*ORGANISATION NAME*	*SUBNAME*	*GROUP NAME*	*CITY*	*COUNTRY*
Dr. J.W. Metselaar	Delft University of Technology	Faculty of Information Technology and Systems (ITS)	Division DIMES	Delft	Netherlands
Dr. M. Zeman	Delft University of Technology	Faculty of Information Technology and Systems (ITS)	Division DIMES	Delft	Netherlands
Dr. B.J.R. Scholtens	DSM Research B.V.	New Business Development		Geleen	Netherlands
Drs. W.O.J. Böttger	Ecofys Energie- en Milieuprojecten			Utrecht	Netherlands
Dhr. E. Knol	EDON NV	Duurzaam		Zwolle	Netherlands
Ir. E.J. Koot	Ekomation	Environmental & Energy Consultancy		Rotterdam	Netherlands
Ing. C.W.A. Baltus	Elektro Advies Bureau Baltus			Valkkoog	Netherlands
Ing. J. Smit	ENECO NV		ES en S	Rotterdam	Netherlands
P. Niermeyer	EnergieNed			Arnhem	Netherlands
Ir. E.A. Franke	Franke Architekten BV			Sliedrecht	Netherlands
Dhr. P. van der Vleuten	Free Energy Europe B.V.			Eindhoven	Netherlands
R. Gengler	Gemeente Emmen			Emmen	Netherlands
P. Klep	Gemeente Etten-Leur			Etten-Leur	Netherlands
L. Mutsaers	Gemeente Tilburg	Dienst Stadszaken/Milieu		Tilburg	Netherlands
S. van Egmond	Greenpeace	NL	Klimaatverandering & Energie	Amsterdam	Netherlands
Ir. H. van Zwieten	Han van Zwieten BNA	Architectuur en Zonne-energie		Zeist	Netherlands
Dhr. R.G.A. Bult	Hügli Pollock Read Industriele Marketing BV			Utrecht	Netherlands
Mr. M. van den Heuvel	KEMA	Registered Quality BV		Arnhem	Netherlands
J.F. Groeman	KEMA	T & D Power		Arnhem	Netherlands
B. Veltkamp	Level Energy Technology			Son	Netherlands
Ir. H. Marsman	Mastervolt Solar BV	tailor made energy		Amsterdam	Netherlands
Mw.drs. E. Butterman	Mercire BV			Utrecht	Netherlands
Th. De Jong	Milieudienst Zuid-Oost Utrecht			Zeist	Netherlands
Ir. A. Bultink	Ministerie van Economische Zaken (EZ)	Projectbureau Duurzame Energie (PDE)		Arnhem	Netherlands
Mr.drs. H.C. Wouters	Ministerie van Economische Zaken (EZ)	Projectbureau Duurzame Energie (PDE)		Arnhem	Netherlands
Ing. W.C.H.C. Jansen	Ministerie van Volkshuisvesting, Ruimtelijke Ordening en Milieubeheer	Rijksgebouwendienst (RGD)	Directie Ontwerp & Techniek	The Hague	Netherlands
B.J. de Boer	Netherlands Energy Research Foundation (ECN)	Unit Solar & Wind Energy	Duurzame Energie in de Gebouwde Omgeving (DEGO)	Petten	Netherlands
Dr.ir. H.F. Kaan	Netherlands Energy Research Foundation (ECN)	Unit Solar & Wind Energy	Duurzame Energie in de Gebouwde Omgeving (DEGO)	Petten	Netherlands
Dhr. K.H.T.J. van Otterdijk	Netherlands Energy Research Foundation (ECN)	Unit Solar & Wind Energy	Duurzame Energie in de Gebouwde Omgeving (DEGO)	Petten	Netherlands

Table C.4 *List of PV-experts who have returned the questionnaire and indicated that they would like to receive a report of this study*

NAME	*ORGANISATION NAME*	*SUBNAME*	*GROUP NAME*	*CITY*	*COUNTRY*
Dr. J.A.M. van Roosmalen	Netherlands Energy Research Foundation (ECN)	Unit Solar & Wind Energy	Section PV Cells & Modules	Petten	Netherlands
Dr. A. Schönecker	Netherlands Energy Research Foundation (ECN)	Unit Solar & Wind Energy	Section PV Cells & Modules	Petten	Netherlands
Drs. F.D.J. Nieuwenhout	Netherlands Energy Research Foundation (ECN)	Unit Solar & Wind Energy	Section PV Systems	Petten	Netherlands
Drs. M. van Schalkwijk	NOVEM (Nederlandse Onderneming voor Energie en Milieu)	NOZ-PV team		Utrecht	Netherlands
Ir. M. Quené	NUON NV (Energie-Onderneming voor Gelderland, Friesland en Flevoland)			Arnhem	Netherlands
Mw. I. De Jong	OJA-Services			Eindhoven	Netherlands
Ir. H. Oldenkamp	OKE-Services			Eindhoven	Netherlands
A. Visser	Projectbureau Energie 2050			Den Bosch	Netherlands
L. Lindeman	Projectbureau Leidsche Rijn Utrecht			Utrecht	Netherlands
Ir. C.J. Schroot	REMU NV (Regionale Energie Maatschappij Utrecht)	hoofdkantoor		Utrecht	Netherlands
Ing. F.A.J.K.M. Vlek	REMU NV (Regionale Energie Maatschappij Utrecht)	hoofdkantoor		Utrecht	Netherlands
Dr.Ing. J.L.M. Renckens	Renckens Advies Geveltechnisch Bureau BV			Nijmegen	Netherlands
Dhr. R. Knoppers	Rijkert Knoppers Tekstproducties			Den Bosch	Netherlands
D. Hillcox	Ove Arup & Partners			Newcastle upon-Tyne	United Kingdom
Dr. S. Roaf	Oxford Brookes University	School of Architecture		Oxford	United Kingdom
D.L. Jones	Studio E Architects			London	United Kingdom
Dr. N. Pearsall	University of Northumbria	NPAC		Newcastle upon-Tyne	United Kingdom
A.M. Barnett	AstroPower, Inc.			Newark	United States
J. Wohlgemuth	BP Solarex	U.S.		Frederick	United States
J.I. Hanoka	Evergreen Solar, Inc.			Waltham	United States
L.M, Fraas	JX Crystals Inc.			Issaquah	United States
J. Gee	Sandia National Laboratory	Photovoltaics Department		Albuquerque	United States
S.J. Strong	Solar design Associates, Inc.			Harvard	United States
C.E. Witt	U.S. Department of Energy	National Renewable Energy Laboratory (NREL)		Golden	United States
R. Perez	University Albany	Center for Environment Science and Technology Management (CESTM)	Atmospheric Sciences Research Centre (ASRC)	Delmar	United States

ANNEX D BASIC DATA INPUT USED FOR THE ANALYSIS

Table D.1 presents the uncorrected values for questions 2 to 15. The figures only represent the 'Significance values' of the variables classified to region. The 'Numbers' are not constant for the regions Europe, Asia and the Netherlands. Some respondents have not filled in all the questions. A blank question is represented in SPSS with the Figure 0. A case with a zero is skipped when the mean or standard deviation is calculated. All American respondents filled in all the questions, so that their 'Number' is constant.

Table D.1 *Significance of the variables*

	America				Europe				Asia			
	HIGH	AVERAGE	LOW	NO OPINION	HIGH	AVERAGE	LOW	NO OPINION	HIGH	AVERAGE	LOW	NO OPINION
Financing	14	2			58	9	2		7	4		
Cost reduction	13	3			59	9	1		6	3		3
Spatial planning, regulation & licensing	4	10	2		27	33	8	1	7	1	3	
Other elements influencing market introduction	7	9			24	33	12	5	3	4		
Environmental merits	7	9			50	15	4		7	5		
Technical reliability	13	3			59	10			6	6		
Product diversity	5	7	4		30	31	8		5	5	2	
Standardisation	10	4	2		40	25	4		7	4	1	
Specialist knowledge	10	4	2		54	9	6		9	1	2	
Image	12	2	2		50	14	4	1	8	3	1	
RD&D	13	3			51	16	2		6	6		
The PV network	7	9			35	31	2	1	9	3		
Internationalisation	7	9			31	28	9	1	8	3	1	
Global developments	8	5	2	1	37	20	11		8	4		

Table D.2 presents the uncorrected values for the questions 2 to 15. The figures only represent the 'Status values' of the variables classified to region. The 'Numbers' are not constant for the regions Europe, Asia and the Netherlands. Some respondents have not filled in all the questions. A blank question is represented in SPSS with the Figure 0. A case with a zero is skipped when the mean or standard deviation is calculated. All American respondents filled in all the questions, so that their 'Number' is constant.

Table D.2 *Status of the variables*

	America					Europe					Asia				
	GOOD	SUFFICIENT	INSUFFICIENT	POOR	NO OPINION	GOOD	SUFFICIENT	INSUFFICIENT	POOR	NO OPINION	GOOD	SUFFICIENT	INSUFFICIENT	POOR	NO OPINION
Financing		1	11	4		6	16	32	13	2	3	3	5		
Cost reduction		2	12	2		1	14	46	8			4	7	1	
Spatial planning, regulation & licensing		4	9	2	1		18	30	17	4		3	6	2	
Initiatives influencing market introduction		2	12	2		3	24	31	9	2		4	4	4	
Environmental merits	4	4	7	1		14	28	21	6		4	5	2	1	
Technical reliability	2	7	7			5	44	17	2	1	5	3	4		
Product diversity		5	6	5		6	22	27	13	1	1	4	6	1	
Standardisation		4	11	1			18	37	11	3		6	6		
Specialist knowledge			10	6		2	9	38	20				4	8	
Image		2	11	3		10	26	25	8		2	7	2	1	
RD&D		4	11	1		8	30	29	2		4	6	2		
The PV network		10	2	4		2	20	33	11	3		1	7	4	
International co-operation	1	7	7	1		6	26	29	3	4		5	4	3	
The interaction		9	4	2	1	2	19	32	11	3	2	3	6	1	

Table D.3 on the next page presents the values for the b-questions 2, 5, 7, 8, 11 and 14. The figures only represent the frequency that an option is ticked classified per region.

Table D.3 *Crosstabulation of the b-questions 2, 5, 7, 8, 11 and 14*

	America		Europe		Asia		Netherlands	
Question 2	*N*	*%*	*N*	*%*	*N*	*%*	*N*	*%*
Lease constructions	2	5.7	9	6.2	1	3.8	21	18.9
Pay back tariffs	4	11.4	34	23.3	5	19.2	22	19.8
Green power	8	22.6	38	26.0	3	11.5	24	21.6
Subsidies	10	28.6	29	19.9	8	30.8	22	19.8
Tax measures	9	25.7	31	21.2	8	30.8	34	30.6
Other	2	5.7	5	3.4	1	3.8	8	7.2
Total	*35*	*100.0*	*146*	*100.0*	*26*	*100.0*	*111*	*100.0*
Question 5	*N*	*%*	*N*	*%*	*N*	*%*	*N*	*%*
Autonomous PV	4	16.7	32	25.0	3	12.5	17	17.3
Social organisations	5	20.8	37	28.9	4	16.7	46	46.9
Niche markets	4	16.7	21	16.4	4	16.7	12	12.2
Pioneering activities	11	45.8	27	21.1	10	41.7	13	13.3
Other	0	0.0	11	8.6	3	12.5	10	10.2
Total	*16*	*100.0*	*69*	*100.0*	*12*	*100.0*	*61*	*100.0*
Question 7	*N*	*%*	*N*	*%*	*N*	*%*	*N*	*%*
Certification & standardisation	12	42.9	46	36.2	10	40.0	39	41.5
Commissioning tests	2	7.1	18	14.2	6	24.0	11	11.7
Guarantees	10	35.7	47	37.0	6	24.0	36	38.3
Other	4	14.3	16	12.6	3	12.0	8	8.5
Total	*24*	*100.0*	*128*	*100.0*	*24*	*100.0*	*98*	*100.0*
Question 8	*N*	*%*	*N*	*%*	*N*	*%*	*N*	*%*
Power (Wp)	3	8.8	21	14.1	6	19.4	14	10.6
Colour	5	14.7	15	10.1	4	12.9	23	17.4
Dimension	8	23.5	37	24.8	5	16.1	27	20.5
Electrical grid connection	6	17.6	15	10.1	5	16.1	16	12.1
Mounting systems	10	29.4	51	34.2	10	32.3	42	31.8
Other	2	5.9	10	6.7	1	3.2	10	7.6
Total	*28*	*100.0*	*127*	*100.0*	*25*	*100.0*	*94*	*100.0*
Question 11	*N*	*%*	*N*	*%*	*N*	*%*	*N*	*%*
Environmental awareness	12	38.7	61	40.1	8	42.1	46	30.3
Independence	6	19.4	17	11.2	4	21.1	16	10.5
High-tech	4	12.9	26	17.1	1	5.3	33	21.7
Luxury	0	0.0	9	5.9	1	5.3	13	8.6
Trend setting	6	19.4	36	23.7	3	15.8	31	20.4
Other	3	9.7	3	2.0	2	10.5	13	8.6
Total	*31*	*100.0*	*152*	*100.0*	*19*	*100.0*	*152*	*100.0*
Question 14	*N*	*%*	*N*	*%*	*N*	*%*	*N*	*%*
Development aid	8	22.2	29	17.4	9	28.1	10	8.3
Distribution & trade in PV power	4	11.1	15	9.0	6	18.8	19	15.7
Harmonisation of policy	6	16.7	39	23.4	7	21.9	32	26.4
Transfer to low income countries	6	16.7	15	9.0	4	12.5	7	5.8
RD&D	4	11.1	29	17.4	2	6.3	24	19.8
Regional introduction programmes	5	13.9	32	19.2	3	9.4	24	19.8
Other	3	8.3	8	4.8	1	3.1	5	4.1
Total	*36*	*100.0*	*167*	*100.0*	*32*	*100.0*	*121*	*100.0*