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# Acceptability of Solar Power Systems

A Study on Acceptability of Photovoltaics with Special Regard to the Role of Design

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## A Study on Acceptability of Photovoltaics with Special Regard to the Role of Design

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## Summary

The generation of solar power (photovoltaics, PV) will play an important role for a sustainable global energy supply in the future. Solar power is environmentally friendly, does not release greenhouse gases and represents a peaceful alternative to the fossil and radioactive energy sources currently dominating the world's energy supply. These "conventional" energy sources are scarce and may increasingly lead to conflicts. However, the spread of solar power faces various restraints. Up to now, research has covered mainly technical and economical aspects of this still comparatively costly power generation technology. But these aspects are not the only issues as far as the integration of PV as an architectural and functional element of buildings and landscapes is concerned. Too little consideration has been given to other factors of acceptance like the issue of design. To further explore design issues the European research project PVACCEPT was created. In this project, designers and solar companies cooperated in the development of innovative, marketable PV modules and applied them in several demonstration objects. The demonstration sites - mainly historical buildings under monumental protection in tourist areas - represented the maximum challenge for the integration of photovoltaics and promised positive multiplier effects as well as a contribution to soft tourism. This report illustrates the results of the accompanying acceptability study within PVACCEPT, including interviews with citizens, tourists, architects and members of monument conservation departments. The results confirm the previously underestimated role of design and identify an urgent need for further information, education, regulation and R&D activities.



## Zusammenfassung

Die Erzeugung von Solarstrom (Photovoltaik) wird einen wichtigen globalen Beitrag für eine nachhaltige Energieversorgung der Zukunft leisten. Solar erzeugte Energie ist umweltfreundlich, schützt das Klima und stellt eine friedliche Alternative zu den knapper werdenden und konfliktträchtigen fossilen und radioaktiven Brennstoffen dar. Dennoch ist Solarstrom vielfältigen Hemmnissen ausgesetzt. Bisher werden überwiegend die technischen und ökonomischen Hemmnisse der noch vergleichsweise teuren Energieerzeugungstechnologie thematisiert. Diese Aspekte spielen jedoch bei der Integration von PV als gestalterisches und funktionales Element in Gebäude oder Landschaften nicht immer die wesentliche Rolle. Bislang zu wenig berücksichtigt wurden andere Akzeptanzfaktoren, wie z.B. die Gestaltung und die Rolle von Designaspekten. Diesem Aspekt ging das europäische Forschungsprojekt PVACCEPT nach, in dessen Rahmen innovative, marktfähige Module von Designern und Solarfirmen gemeinsam entwickelt und in Demonstrationsprojekten angewendet wurden. Die Objekte und Standorte – überwiegend denkmalgeschützte Gebäude in touristischen Gebieten - stellten die größtmögliche Herausforderung für die Integration von Photovoltaik dar und versprachen gleichzeitig positive Multiplikationseffekte sowie einen Beitrag zu einem sanften Tourismus. Die vorliegende Arbeit stellt die Ergebnisse der begleitenden Akzeptanzstudie zum Projekt dar, in der u.a. Bürger, Touristen, Architekten und Denkmalschützer zum Thema befragt wurden. Die Ergebnisse bestätigen die bisher unterschätzte Rolle von Designaspekten und zeigen gleichzeitig Informations-, Bildungs-, Regulierungs- sowie F&E-Bedarfe auf.


## Main Author and Contributions


Bernd Hirschl is coordinator of the "sustainable energy and climate protection" unit of the Institute for Ecological Economy Research (Institut fuer oekologische Wirtschaftsforschung, IOEW), Berlin. He studied engineering and economics at the Technical University in Hamburg-Harburg and Hamburg University and has been working for IOEW since 1998. His research fields cover markets, political framework conditions and economic, ecologic and social aspects of energy systems (especially renewable energy systems) as well as climate protection activities and policies. The study was executed together with the Italian Partner Ambiente Italia and the University of Arts, Berlin. Several IOEW-colleagues also worked with PVACCEPT over the years and contributed to parts of research and this report.

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# 1 Introduction

Renewable energy power generation will play a major role in achieving a transformation towards a more sustainable energy system by effectively reducing $CO_2$ and other emissions. Compared to conventional technologies based on fossil fuels, solar energy is an infinite and “peaceful” resource. Photovoltaic (PV) technology that converts solar energy into electricity provides a long term perspective for a sustainable energy system, in addition to significant potential to protect the climate ($CO_2$-reduction). Despite increasing distribution of photovoltaic technology in Europe in the past few years, its share of overall power generation still is at a low level. This fact is due both to technical and non-technical barriers.

Within this context, the aim of the PVACCEPT project was to examine barriers to and potentials of a wider use of this solar technology, and to find answers and (technical) solutions to overcome distribution problems. The project focused on acceptance as an important distribution factor, with special emphasis on the role of design.

The central proposal was that improving the design options for PV (concerning both, the design of PV modules themselves and PV as a design element in architecture and landscapes) would help to broaden the distribution of PV. It was assumed that design has been underestimated and has so far hardly been explored in terms of acceptability. Well designed PV modules could improve acceptance, lead to imitation (multiplier effects) and therefore enhance dispersion. These effects could be strengthened if PV was implemented in “difficult surroundings” such as visible and “outstanding” architecture and landscapes. These ideas led to the concept of PVACCEPT: to create (marketable) design solutions and innovative PV modules in order to introduce their sensitive, discreet or accentuated integration into old buildings, historical sites, and protected landscapes. In other words, an intensified implementation of novel designed, innovative PV modules in tourist areas could create multiplier effects and could help improve the public acceptance of solar technology.

The accompanying acceptability study within PVACCEPT dealt with distribution factors like role of design, multiplication effects and problems of authorisation, which so far have not been examined on a wider scope. The first part of the study was carried out before (“ex ante”); the second part occurred after (“ex post”) the construction of the PV demonstration projects in the two research regions in Germany and Italy. Alongside the examination of general aspects concerning solar powered systems, the goal of this approach was to analyse processes, developments, improvements and also reactions concerning the built PV demonstration objects.

The first part of the acceptability study (2001) was mainly based on questionnaires given to experts and local residents concerning their knowledge about PV, their opinions on aesthetic factors and their willingness to accept PV also on old buildings, monuments and in landscape architecture. Additional information was gathered through direct interviews and talks with experts and key persons at workshops held in Germany and Italy in October and November 2001.

The second part of the study (2003-2004) focused on important actors of the implementation process of PV: architects and (in our case) public authorities. In addition, an evaluation of the built PV demonstration objects and some drafts and visualisations of possible objects took place with local citizens and tourists. Also in this phase we gained additional information from experts and other key persons during workshops and SME trainings in Porto Venere, Italy and Marbach am Neckar, Germany.

The report is structured as follows: In the introduction some general thoughts on the subject and terminology of acceptance in scientific research and public discussion are presented, followed by a description of the general acceptance of renewable energy systems (RES) in some European countries and the respective status of photovoltaics. Next, the main theses of the whole project PVACCEPT and also of this study are presented, followed by a description of the methods used. Chapter 2 deals with the empirical results of both parts of the acceptability study. The focus of the “ex ante” section centers on the knowledge about PV, the role of design and PV in protected tourist areas in general. The “ex post” section deals with important intermediaries such as architects and their knowledge, education and attitudes towards design and aesthetic influences. In addition, supplementary factors of success for PV are described from the way authorisation processes are managed to reactions to the design of the PV installations. These empirical results lead to final conclusions, recommendations and an evaluation of further research needs (chapter 3).

## 1.1 General Acceptance of RES[1] and PV

### *1.1.1 Disciplinary Contexts and Terminology*

Acceptance can be defined generally as a theoretical entity that refers to the adoption of new information with effects on behaviour. The aim of acceptability research can be to examine the willingness to receive (accept) an innovation using instruments of empirical social research. It is used predominantly in marketing and opinion research as well as in psychological analysis to determine characteristics of acceptance for products, instruments or technologies.

The terms acceptance and acceptability are often used inconsistently in the common speech. In some scientific debates they are well differentiated, but unfortunately not always in the same way.

**Acceptance and Acceptability in the Context of Sociological Research**

Acceptance cannot be assessed independently from social norms and values. Dynamic processes with various influencing factors lead to acceptance and represent the result of developments within society. When phenomena like individualisation and pluralism became increasingly popular during the 1980s, scientists realised that subject-related statements could no longer be disregarded (Beck 1986, 113 et seqq.).

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[1] RES: renewable energy systems.

In sociological (as well as psychological) research the difference between attitudes and behaviour is an important issue. Thereby Müller-Böling and Müller's definition of two ideal types of acceptance is helpful (Müller-Böling/Müller 1986, 25 et seqq.):

- Behaviour-oriented acceptance describes a behaviour corresponding to the aims and objectives of the system to be implemented (Schade 2001, 2).
- Attitude-oriented acceptance is an affirmative attitude towards a specific object.

In the context of sociological research, the term *acceptability* is often linked to the estimation of future concepts by collecting attitudes *before* a measure or artefact is introduced. In contrast, acceptance denotes normative statements expressed *after* the implementation, when people are familiar with the measure and show behavioural reactions, guided by previous attitudes (Schade/Schlag 2001, Schrader 2001). Experience is the dominant element leading from acceptability to acceptance.

Many studies indicate there is a significant gap between individual attitude and behaviour, especially concerning environmental awareness and behaviour (see e.g. in Kuckartz 1998). Theoretically adopted values are not automatically put into practice. Regarding the distinction made above, this gap leads to a divergence between acceptance and acceptability of environmental instruments.

**Acceptance and Acceptability in the Context of Technology Assessment**

The terms acceptance and acceptability are also used separately within this scientific debate. In the field of technology assessment, acceptability research means analysing social and economic impacts of new technologies with common empirically oriented methods. In this context acceptability is a crucial requirement for the social acceptance of a technology. Meyer-Abich defines the acceptability of a technology as its "capacity to be adopted in relation to its cultural frame" (Meyer-Abich 1999, 309). Acceptability takes place as discussion between different groups of stakeholders in a given socio-cultural background, eventually reaching political importance. In the long run, only those technologies are "acceptable" which support common cultural ideas and improve the quality of life.

The conclusion to be drawn is that results of the political/social discussion process concerning acceptability may be different from society's acceptance or that of main stakeholders. Moreover, one can record that the discussion about acceptability is the attempt to start a more conscious or rational process leading to a "normative" answer (is a product/technology acceptable?) compared to the more "unconscious or irrational" social acceptance (does society accept a product/technology?) (see also von Gleich 1997).

Various scientists have emphasized necessary aspects to be considered in terms of acceptability discussion. For instance, the Enquete Committee of the German Bundestag, working on the "future of nuclear energy policy" (1979/80), developed a set of four basic criteria for assessing technological problems that affect the national level (Meyer-Abich 1999): economic efficiency, international compatibility, environmental compatibility and social compatibility.

### Terminology of this Study

Both research fields, sociological and technological, differ primarily in the focus on subjects accepted or acceptable by specific target groups. Technology assessment deals with the socio-political level: the subjects are politically more relevant, similar to social target groups (stakeholders), the methods of "political discussions", and the attempt to establish acceptability criteria. Sociological research puts more emphasis on the individual level. Apart from these differences, similarities consist in a certain "chronological order", which means that acceptability as an expression of individual or social (cultural) attitudes ("ex ante") provides the basis for acceptance ("ex post"). In the following study we used this pragmatic distinction, knowing that the terms and concepts are often used similarly "in practise".

### Dimensions of Acceptance

Schrader differentiates between three individual dimensions of acceptance: object (What is evaluated?), subject (Who is evaluating?) and context (What are the influencing actors and factors?) (Schrader, 2001: 128):

- *Objects of acceptance*: During an evaluation, certain objects and their ecological, economical, and social impacts need to be considered. The form of appearance of the objects presents an important influencing aspect. Local circumstances of the objects are also important. Especially their distribution or "visibility" including the distance to the interviewee need to be investigated.

- *Subjects of acceptance*: Biographies of actors involved in an evaluation play a crucial role. Other important variables are their behaviour as well as their perception and attitude, all of which are influenced by social norms and values. Finally, the actors' education and their knowledge about the objects also need to be taken into consideration.

- *Context of acceptance*: The general framework of the evaluated objects is essential to understand the context of acceptance. Likewise it can reveal "formal" aspects of acceptance problems. Influencing actors and relevant stakeholders are to be identified and their roles need to be analysed.

In this context the object of acceptance is photovoltaic technology, particularly specifically designed PV components. The subjects of acceptance are on the one hand the population of our research regions (inhabitants, tourists, possible investors) and on the other hand intermediates or "crucial" decision makers like authorities, architects and craftsmen. These actors can play an important role as relevant stakeholders in investment decisions in favour of or against PV. Additionally, basic conditions like regulations, authorisation processes, and costs are to be taken into account.

## *1.1.2 Acceptance of Renewable Energies*

Due to rising awareness of global warming and climate change within the EU, renewable energies in general have a positive political image as they are considered to be a possible answer. The political engagement in promoting renewable energies is relatively high, especially in front-runner countries like Germany or Spain. Germany plays a leading role concerning the implementation and the success of instruments promoting renewable energies, particularly in the field of photovoltaics (PV). Regardless of the success of renewable energies within many of the EU-member states, there still exist several political and social barriers, as well as unique acceptance problems.

However, the general acceptability and acceptance of renewable energies and especially of solar technologies can be considered to be relatively high.

### General (and unspecific) Acceptability and Acceptance

- According to results of a representative survey, 85% of the German population are in favour of renewable energies (Emnid-Institute, 2004). This result underlines the public interest in climate protection and reveals a high acceptability of renewable energies at a general level.

- Another comprehensive study on behalf of the German Environmental Ministry (Kuckarts/ Rheingans-Heintze, 2004) finds that two thirds of the German population agree (one third even “decidedly” agrees) to an extension of the renewable energy sector.

- The IPSOS-Institute confirms those numbers in an opinion poll for the World Wide Fund for Nature (IPSOS 2003).

- A similar result was obtained by a recent representative survey conducted by ISES Italia and the Kyoto Club in Italy. When asked about their opinion on the 2010 EU target of doubling the energy production from renewables, 46% of respondents answered that Italy should increase measures, being a large importer of energy. Another 42% expressed that Italy should respect EU targets, and only 5% think that this would negatively affect the national economy (ISES/KC 2003).

- In contrast, merely 20% of the French people attach importance to renewable energies within their environmental policies[2] (ADEME 2004).

### Diverse Acceptance on local Level

Even though the general acceptability appears to be strong in Germany, the acceptance of renewable energies includes ambivalent aspects, as well. When asking people about their opinions regarding specific issues of renewable energies, the results are less clear. Hidden behind the general compliance are serious concerns for specific cases. This represents the well-known gap between theory and practice or between attitude and active behaviour. Social scientists (e.g. Fischer 1993) call the phenomenon “NIMBY effect” (Not in my backyard)[3]. Renewable energies have to deal with this problem as they often enjoy a high basic acceptance but lack installation in or near homes or within the daily environment of individuals.

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[2] Responding to the question: “Which actions are to be carried out by the government in environmental issues?” (ADEME 2004)

[3] The NIMBY-effect describes a behaviour of citizens and parliamentary representatives, who want to avoid the negative impacts of for example the look and risks of industry plants in their neighbourhood. In other words the NIMBY-effect describes a political and ethic position which includes ignorance to certain problems in immediate surroundings or the own region.

Compared to the centralised system of fossil-based large-scale power plants, the energy supply of renewables follows a decentralised strategy. Thus, the renewable energy plants obviously outnumber the conventional plants. This consideration explains the frequent public awareness during licensing and construction of renewable energy plants. Simply because their high numbers make them more visual, solar panels and windmills nowadays enjoy a high attention at least in “front runner” countries. Increasing promotion of decentralised (but “visual”) renewable energy technologies in those countries has lead to an increase in public awareness and sensibility. If the selection of appropriate sites does not account for the local interest and acceptability, this may lead to significant barriers for further implementation and could result in a negative “snowball effect” beyond the local “single case”.

The widespread general acceptance of renewable energies, as reflected in people’s attitudes, can be explained by the positive values attributed to them. For many people renewable energies stand for social progress, a clean environment and for political action against climate change. However, the “NIMBY effect” reduces universal acceptance when it comes to individual behaviour (see above) depending on “visibility” and distance of power plants to the target group.

**Ecological Acceptance**

The impact of renewable energies on environmental systems is especially a matter of particular (and not general) acceptance of renewable energies. Due to a broad variety of renewable energy technologies, distinctions need to be made in regard to the specific environmental impacts. These impacts play an important role in the public discourse over acceptance, which is also highly affected by emotional perception.

In terms of *nature conservation* environmental functions include biotic, abiotic and aesthetic aspects within the ecosystem. Interferences of such environmental functions can lead to complex consequences for ecosystems. If construction and operation of renewable energy plants collide with principles of nature conservation, public acceptance decreases. This happened with wind turbines, which are considered to endanger wildlife like migratory birds and which influence the aesthetic functions of a landscape. According to the results of a survey by Kuckarts/Rheingans-Heintze (2004), the impact of wind turbines on natural scenery divides the German public into two equal parties: 49% are not in favour of windmills, whereas 51% do not see any negative influences on landscapes. Questioned in a different way 82% of Italians approve an installation of windmills on their own territory if requirements for a proper integration into the landscape are respected (ISES/KC 2003 - Regarding this question, the response of the German population would be of great interest). Other examples are the ecological and visual impacts of barrages and dams or the ecological problems of monocultures that may result from the cultivation of energy plants.

The *environmental surroundings* of the location of renewable energy plants affect their ecological acceptance. There is a great difference between plants operating in ecologically sensitive and natural areas and plants located in post-industrialised, man-made landscapes.

Finally the *energetic pay back time* is discussed in regard to the ecological benefits of a renewable energy technology and its ecological acceptance. The argument of very high energetic pay back times used to be brought up frequently against PV technologies. However, nowadays this argument is less common, as it has been shown by various studies that the *energetic amortisation* of conventional silicon-based plants is about three to five years (Fockenbrock/Peters 2004), whereas that of new cell types like thin film cells is only about one year. In contrast, their lifetime is about 20 to 30 years.

### Economical Acceptance

The economical part of acceptance has to do with the general *cost situation* of a technology. The disadvantage of the still (comparatively) costly PV technology can be compensated with adequate subsidies or other financing mechanisms (as for example in Germany, Spain, and Japan). On the local level the economical part of acceptance addresses an additional aspect: if local residents are able to share the economic benefit of a renewable energy project (e.g. as owner/shareholder of windmills or solar parks) the acceptance is likely to be influenced positively. On the other hand, the same economic considerations can also lead to negative acceptance: the perception of unacceptably high levels of costs, high subsidies, long economic payback time etc. lowers the economical acceptance. The willingness to pay can indicate a “margin for distribution”. In an Italian survey almost 70% of the population expressed a very high disposition to buy green electricity, but just 14% were willing to pay more than 10€ per month for it (ISES/KC 2003).

### Socio-cultural Aspects and Knowledge

Various socio-cultural aspects also play a role in determining the acceptance of renewable energies. It can be assumed that the socio-cultural aspects are coupled with individual biographies, including personal background and status. In the Italian survey mentioned above, it was found that the commitment to an Italian “pro renewables” strategy (i.e. the installation of wind power plants) correlates with education and status; respondents from the group of less educated people and the group of housewives were most likely to oppose this kind of policy (ISES/KC 2003).

Therefore the degree of *education and information*, and ultimately the *individual knowledge* about renewable energies influence acceptance. The German study from Kuckarts and Rheingans-Heintze (2004) showed that 48% of the German population justifies their reluctance to purchase “green” power with lack of information. The study of ISES/Kyoto Club indicates the same correlation: the majority of people in favour of renewable energies in Italy are independent workers and live in the more prosperous North-East of the country (ISES/KC 2003). It is therefore obvious that a lack of knowledge leads to lower acceptance.

While renewable energies enjoy a comparatively high acceptability in general, there still appears to be a significant lack of knowledge concerning a lot of important issues like functioning, ecological and technological aspects, their role in a future energy system and their role as climate-protecting technologies. Better knowledge about these issues could lead to an increase of acceptance. It needs to be considered that each single category of renewable energy, like solar, wind, biomass, and water has its own distinctive profile regarding acceptance.

Finally the aesthetic perception of renewable energy plants has to be mentioned as a subjective and emotional aspect which is crucial within socio-cultural patterns. Whether a windmill appeals to a person, possibly because it is regarded as a sign of technological progress and innovation, or displeases him or her, evidently depends on personal perceptions and the corresponding socio-cultural setting.

In summary, the significant general approval in public needs to be looked at more closely in regard to certain aspects concerning location, compatibility with aims of nature conservation and other ecological aspects as well as people's education and their knowledge about renewable energy technologies. These influencing factors are not to be seen independently from one another, but rather correlate in many ways.

### *1.1.3 Acceptance of PV Technologies*

Within the renewable sector, solar energy enjoys a particularly positive image. A solar panel is seen as a sign of "peaceful" change within the energy industry. Contrary to other energy sources, the list of favourable attributes is long: continuous, quiet, clean, emission-free, maintenance-free, and small scale operation (see for example Möller 1999). As for renewable energy technologies in general, there are a number of surveys proving that solar technologies have a widespread positive image at a general, attitude-based and unspecific level. In the following we present some examples and describe other relevant aspects concerning acceptance as it was done in the section above.

**General (and unspecific) Acceptability and Acceptance**

- According to P.M. science magazine, 96% of the German population approve solar energy , 81% even believe that if regulations required solar panels to be installed on every roof, the technology could be a real alternative to conventional energy sources (P.M. 2004).
- In Italy solar energy has a very positive image as well: 58% of respondents of the ISES/Kyoto Club survey think that Italy should invest more in solar energy and focus on solar energy as an important technology to help meet the future energy needs of the country (ISES/KC 2003).
- Results of the French ADEME study show that 90% of those interviewed agree that PV should be installed on public buildings and 83% could imagine having a PV system on their own roof (ADEME 2004). In Italy, a remarkable majority of 89% would favour a law to install solar systems on every new building (ISES/KC 2003).

Again, the difference between attitudes and behaviour needs to be kept in mind. The willingness to pay approach or the mentioned "NIMBY effect" could lower the (acceptability) figures when it comes to "real life" questions of acceptance.

**Technical and economical Aspects affecting Acceptance**

Technical and economical aspects of PV usually dominate the discussion about distribution and acceptance of PV. Solar technologies are still comparatively costly (compared to grid-based technologies and not taking into account external effects), although prices have gone down significantly in the past decade. Cost effectiveness of PV technologies is highly dependent on the existence and design of support programmes and subsidies, which also determines their economic barriers and acceptance problems.

General technical and/or economic barriers and opportunities can be described as follows (see also Forum für Zukunftsenergien 1997):

- Low price level of conventional energies (based on actual primary energy resources);
- Centralised energy systems and large-scale power plants;
- Research, development and support (loan) policies for renewable energy technologies;
- Technical and economical conditions to feed energy into the existing electricity grid; (e.g. feed-in payments, costs for grid-use, degree of liberalisation)
- Solutions for the integration of fluctuating power generation from renewable energy technologies (depending on the weather and climate);
- Further legal and administrative conditions (e.g. concerning technical approval etc.).

**Ecological Acceptance**

As mentioned above, several studies have shown that PV technology has clear ecological benefits. When comparing photovoltaic power generation to the current energy mix generated by German power plants, one study found that PV technology has a $CO_2$-reduction potential of 60% (Hagedorn 1997, Quaschning 1999). Yet another study has confirmed a comparatively low life-cycle impact of PV (calculated value: 60g$CO_2$/kWh, see Frankl et al. 2004).

Today, the evaluation of the energetic performance of PV technology, using indicators like energetic amortisation time or energetic payback period, is not an issue within the scientific debate. Several studies have shown positive results (see Hagedorn 1997, Staiß 2000) due to energetic savings through mass production effects as well as rising production and product efficiencies – a development that is likely to continue. New materials and thinner layers could save more energy and costs in the future. In Germany the energy pay back time of an average PV power plant is three to five years with an expected life time of 20 to 30 years. In sunnier locations, a lower pay back time can be achieved with the same technology.

Nevertheless, it might be an issue in public debates that PV systems still need “a few years” to generate the energy needed for their production, especially when compared to other renewable energy technologies. For example, the average wind power plants have an energetic pay back time of only a few months (Fockenbrock/Peters 2004). This consideration could reduce the public’s ecologically motivated acceptance.

The general ecological relevance of the production of photovoltaic systems and the materials used was addressed in several studies dealing with life cycle analysis. The results show that no significant risks could be found and that the materials used are of little harm to human beings and the environment (e.g. Hagedorn 1997, Wagner/Pfisterer 1993).

With the amendment of the German Renewable Energy Act in 2004, solar power plants in open space (those that are not connected to buildings) have become an explicit part of the promotion concept of the German government.[4] The amendment intended to boost industrial mass production and accelerate economies of scale. On the downside, the emergence of solar power plants in open space may lead to discussions about ecological and aesthetic aspects of such plants, as reactions of environmental non-government organisations and citizens have already shown. A Forsa survey showed that 66% of respondents did not agree with PV in open space (SFV 2003). Meanwhile some practical examples are known, where involved citizens voted successfully to deny a building permission for a megawatt scaled PV project in open space (example of the Schmiechen, Bavaria, see SFV 2004). A sensitive selection of sites and consideration to conservation issues are needed to prevent the solar industry from running into acceptability problems similar to the wind energy sector. In Germany, politicians, involved ministries, the solar industry and environmental organisations have initiated a process trying to find criteria to avoid negative impacts on nature, as well as negative impacts on ecologically motivated acceptance.

### Aesthetic Aspects and Knowledge

PV is a “visible” technology. In some cases its visibility is limited (on the roof) in other cases it is prominent. However, composed and designed integration of PV into its surroundings usually does not take place. In contrast, it is hardly ever diverged from the standard modules of dark black or blue colour and rectangular shape. Design aspects that could affect the aesthetic perception (or acceptance) are colour, material, scale, form and the local environment of a PV system.

When integrated into a facade, PV becomes a part of architectural design. The way an investor chooses his or her architectural style is based on individual preferences, but is also embedded in a *socio-cultural context*. Different contexts, for example *country-specific ones*, can lead to different consequences regarding PV integration. In Italy the specific architectural style (e.g. “Mediterranean”) and the higher number of old buildings or areas under monumental protection could play a role in this regard.

The *role of design* aspects was addressed in a survey of the French Environment and Energy Management Agency (ADEME). ADEME asked for motives for or against the use of PV. To the question of why they won’t install PV on their homes, the respondents answered as follows: Given a set of possible answers, 31% replied that they are bothered by the looks of the standard PV modules, while only 16% said that PV is too expensive and 6% thought that PV is not suitable for the French climate in general (ADEME 2004). In this study a remarkably high percentage of respondents expressed more concerns with the role of aesthetics than with economic factors.

The need for *knowledge* and education appears to be high in the case of solar technology. For example, there are diverse technology options, the functionality and the integration in existing technological systems are not self-explanatory, the market is still comparatively small (supply problems) and financing instruments as well as existing subsidy schemes are

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[4] Before this amendment the German Renewable Energy Act addressed mainly small scale plants on the roof, while larger plants were limited to a size of 100 $kW_p$.

often complex and hidden. On the other hand, the general acceptability rate of PV is very high – even without such explicit knowledge. But if additional information was given to the public, the acceptance *and* the distribution rate could rise further. It is therefore likely that imitation effects and face-to-face communications on the local level can play an important role to raise distribution.

## 1.2 Background, Main Theses and Aims of the Study

The following paragraphs discuss the main assumptions, theses and aims of the entire PVACCEPT project that were relevant for this study.

1. There are barriers and acceptance problems beside the dominating technical and economical aspects that influence the distribution of PV.

With this basic thesis we argue that within the context of PV (and of other new technologies as well), distribution is not only based on techno-economical factors but also on a wide range of socio-cultural aspects. As any lack of acceptance will hinder a broader distribution of PV, all relevant factors of acceptance have to be regarded in order to help find solutions to overcome barriers and achieve higher market penetration.

2. A key part of the attempt to increase the distribution of solar technologies and PV lies in the improvement of knowledge.

Based on the assumption that PV related knowledge (concerning the general functioning, availability, relation to climate change etc.) is still limited, this lack of knowledge and information is one of the most important socio-cultural factors slowing down the distribution of PV. Education deserves further attention both on the demand-side (possible investors) and on the supply-side (architects and craftsmen). Studies should therefore address PV related knowledge among the general public and selected actors in the field, such as intermediates and multipliers.

3. To increase the distribution of PV technologies it is necessary to develop more design variations.

The perception of and attitude towards the appearance of a “visible object” like PV can be an important acceptance factor. PV is usually an additional element to buildings and not an integral part of architecture. Although the integration into architecture is and will likely remain a main field of study, design variations of PV modules are still very limited. Improved design of PV modules (colour, shape etc.) can therefore play an important part in raising acceptance rates and distribution. In this regard, research about individual attitudes towards and perceptions of the appearance and characteristics of “standard” and innovative PV design options play a key role.

4. Tourism can be seen as a market for PV - and can be used for the transfer of information and for marketing purposes (creating multiplier effects).

Tourist areas are highly frequented regions, providing favourable conditions for marketing and advertisement. An increased implementation of well-integrated PV technology in tourist areas with either conventional or modern design could create positive multiplier effects. In addition, PV technology fits well into the concepts of soft (or eco-) tourism.

5. If a design (of innovative PV modules and applications) can overcome integration barriers in highly sensitive areas which are under landscape and monument protection (like in many tourist areas), it can be applied successfully in nearly all other locations.

Protected areas and monuments often have stringent requirements for the implementation of new technologies like PV. In some countries, protected areas are vast and at present the application of solar technologies is in many cases prohibited in these regions in general. Conversely, these areas attract tourists and can initiate multiplier effects on the public which could enhance distribution of solar technology. A promising approach to overcome application barriers is to work on "design solutions" and to develop innovative and variable PV modules that can also be applied in such sensitive surroundings.

## 1.3 General Methodical Approach

The general methodical approach of the study is linked to central research aspects mentioned above, like design and knowledge or barriers and chances in tourist areas. Furthermore, the examination of important intermediates plays an important role. The research regions in Germany and Italy should be handled in a very similar way in order to gain comparable case studies. The results of the first part of the study ("ex ante", before the building of PV demonstration objects within PVACCEPT) influenced the form of the second part ("ex post") of the study and the methods used within it.

### *1.3.1 Methods of "Ex Ante" Study*

The first part of the acceptability study was carried out during the first phase of the project (July until December 2001) and had two main goals: a general analysis of acceptance related questions and the preparation of the planned local activities (basically the PV demonstration objects) of PVACCEPT in the selected regions in Germany and Italy. Activities of the project itself, like workshops and negotiations with local actors, provided important inputs for the acceptability study and influenced the following actions. In the "ex ante" study experts and civilians were questioned. The main topics of the "ex ante" study were general knowledge, attitudes towards design aspects and towards the presence of PV technology in protected and tourist areas. These subjects were empirically addressed in comparable, but country-specific workshops, interviews and population surveys.

- **Workshops** with local participants of the Italian and German research regions formed a central element of the first project phase (about 50 participants in each country). These workshops had multiple functions in connection with the acceptance of PV in general and the intended creation of PV demonstration objects. Additionally, the workshops were meant to improve local acceptance. The aim of the workshops was to learn about specific barriers facing PV in these regions as well as specific problems that local people may have with PV technology and their general attitude towards it. The workshops brought together key actors of the research regions. They also provided a common level of knowledge about PV technology to the participants. Finally, a group of possible attractive and acceptable PV demonstration sites was selected for each region.

- **Survey of regional Key Actors**: The workshop participants, additional local experts and key persons were interviewed separately with standardised questionnaires. The return rates in Italy and Germany were similar: 23 questionnaires were returned in each country, most of them workshop participants, including a great variety in professions, functions and institutions.

- **Survey of Local Population** (“Non-Experts”): The third and most extensive empirical part consisted of the enquiry of the local population (“non-experts”) in Rügen, Mecklenburg-Vorpommern, Germany and Regione Liguria, Italy. The composition of questions was similar to the survey of regional key actors. Nevertheless, some special characteristics of the target group, especially their status as “non-experts” needed to be considered and national differences concerning the level of information had to be taken into account. Due to an expected significant difference concerning “solar technology knowledge” within the two surveyed populations, we chose different methods of implementation. In Germany oral surveys were conducted by telephone (higher degree of knowledge, 222 cases), whereas in Italy written questionnaires were used which needed to be retrieved (81 cases). Although the methods differed and no representative sample could be extracted, the results seem to be significant and comparable.

### *1.3.2 Methods of “Ex Post” Study*

The main results and developments of the first part of PVACCEPT influenced the design of the second part of the acceptability study. Changes in the planned locations of demonstration projects in Germany led to an adjustment of the empirical design[5]. The focus of the second part shifted to some extent from the examination of specific developments in the research regions to more general aspects.

The role and attitudes of *architects* as important intermediates for the distribution of PV need to be examined when addressing the relation of aesthetics, design and PV technology (cp. Hold 2002). Regarding the problem of local implementation in protected areas, the administrative situation and authorisation processes have to be analysed and the role and attitudes of authorities investigated. Therefore we focused on these two important target groups. Finally, we asked for (“ex post”) reactions after the building of the PV demonstration objects.

- **Architects survey**: Quantitative Part in Both Countries: In Germany the questionnaires were distributed via a specific internet platform addressing architects dealing with photovoltaics (return: 16 cases). In Italy we sent e-mails to 300 architects who teach in universities or work as independent professionals all over the country (return: 27 cases). The structure and contents of the questionnaires were identical. Since the quality of answers

[5] The solar project in Rügen, Mecklenburg-Vorpommern, Germany could not be realised. Instead, a PV object in Marbach, Baden-Württemberg was implemented.

of the German internet-based questioning was comparatively low, some qualitative interviews were added. A qualitative part was therefore added to the survey in Germany; six in-depth telephone interviews with selected architects (professional solar architects) were carried out to receive more information about the situation in Germany.

- **Analysis of local authorisation problems / Interviews and workshop**:

  - In the **Italian Research Region** a **regional workshop** took place at the end of September 2004, followed by SME training. Participants were local authorities and representatives of the National Environmental Ministry, interested SMEs, associations and researcher groups (total: 40 participants). The workshop was a forum for the dissemination of knowledge on existing or prospective examples of PV technology in protected areas and gave an overview on incentives and other financial measures aimed at fostering PV distribution. Another goal was to improve the transparency of current authorisation procedures in protected areas and to identify best practices in order to handle regulation and permission constraints. On a social level, the workshop enhanced communication and networking amongst the participants.

  - In **Germany, several in-depth-interviews** were conducted and written questionnaires were distributed among different actors involved in the authorisation process. The interviewees included representatives from Rügen, Mecklenburg-Vorpommern (where the building of a PV demonstration object was planned) and Baden-Württemberg (Region in Germany, where the demonstration project was finally realised). People from both regions were involved in the planning and permission procedures of PVACCEPT demonstration objects. Both positive and negative experiences served as important sources of information.

- In the end **local feedback on the PV demonstration objects** (“Ex-Post evaluation”) was obtained to query acceptance of local citizens, tourists and the queried architects (see above). The questionnaire concentrated on aspects like the initial visual impression and the attitude towards PV installations on protected buildings or in protected landscapes.

# 2 Empirical Results

The following chapter discusses the main empirical results of the acceptability study. Section 2.1 deals with the more general conclusions of the first part of the study, while section 2.2 covers the results of the second part dealing with architects, authorisation processes and reactions to the demonstration sites. The structure is divided into different important acceptability factors like knowledge, design, barriers and possibilities in tourist areas (see chapter 1.2).

## 2.1 Results "Ex Ante" Study

The empirical results of the first part of the acceptability study were derived from workshops and various surveys (enquiries of experts and local residents) that had been carried out in 2001 in Germany and Italy.[6] These surveys dealt with the following key questions: What are the different factors leading to or influencing acceptance of photovoltaics, what is the correlation of these factors and how can their impact be described?

### *2.1.1 Knowledge about Solar Technologies and Photovoltaics*

Assuming that knowledge is a fundamental factor of acceptance in general, the investigation of the role, level, character etc. of knowledge related to photovoltaics was an important task during this early phase. Specific questions covered the state of knowledge on solar technologies, promotion policies and subsidies as well as design alternatives.

**General Knowledge of PV**

The first topic of the questionnaires (for residents as well as experts) dealt with basic technical knowledge of solar technologies and photovoltaics. Knowledge of the different heat and power generating technologies may represent a fundamental condition for acceptance.

The surveys within the population indicate that basic technological knowledge in both countries is low: less than one third of respondents knew the difference between solar thermal and solar electric technologies. The German level of knowledge is slightly higher than the Italian (cp. Figure 1). Likely reasons are the higher degree of implementation, education and information level in Germany.

[6] For more detailed information about empirical methods see chapter 1.3. The first part of the acceptability study PVACCEPT is also available as an extended version under www.pvaccept.de.

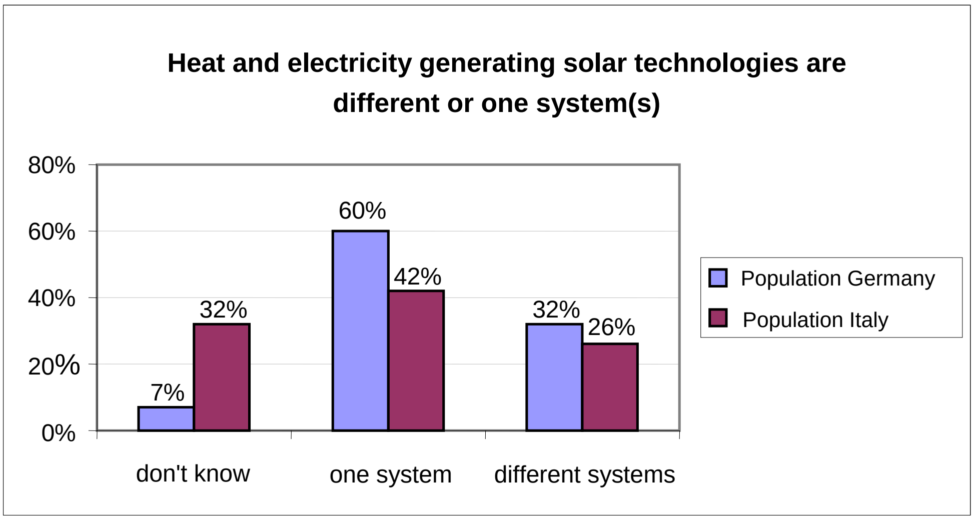


*Figure 1: Population's knowledge of the difference between heat and electricity generating solar plants*

**Knowledge of Support Programmes**

This part of the questionnaire examined awareness of loan or subsidy programmes for PV among experts and citizens, as well as their knowledge about further details on these programmes.

As expected, the majority of Italian and German regional actors knew in general (and at least somewhat in detail) about existing loan or subsidy programmes for photovoltaics. Nevertheless, two Italian and four German respondents of the "expert group" did not know anything about existing financial support.

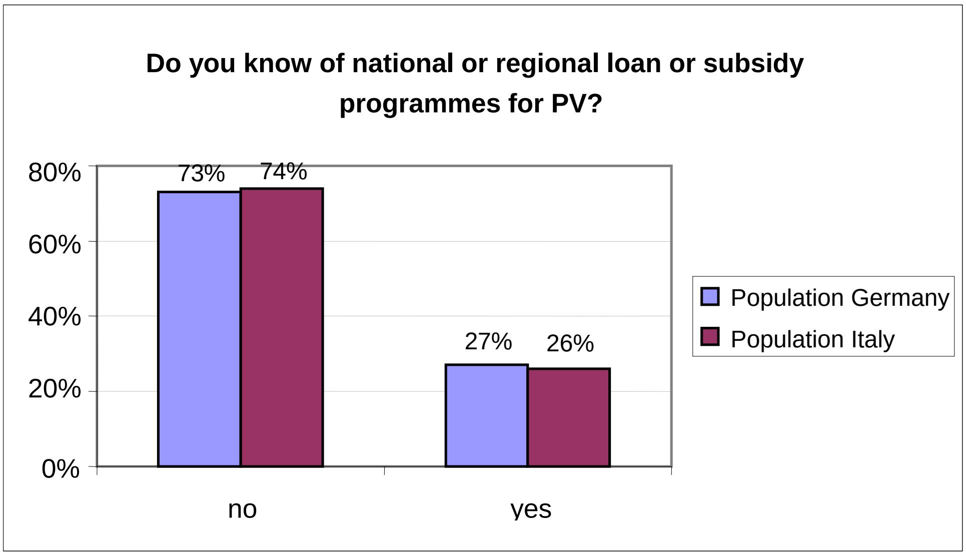


*Figure 2: Population's knowledge about national or regional loan or subsidy programmes for PV*

In contrast, the population's awareness of national or regional support programmes was low again at less than 30% in both countries (cp. *Figure 2*). In Germany the knowledge largely stems from the so-called "100.000-roofs programme" and the "German Renewable Energy

Act" (EEG). The specific knowledge of the corresponding Italian PV roof programme was about 20%.

#### Knowledge on Suppliers of Solar Technology

The recognition of companies in the solar sector is similar in Italy and Germany: about one quarter of respondents know of solar companies in their region. This does not seem to be too low compared to the distribution rates of the technology, the general rate of interest and the knowledge of subsidy programmes (see above).

#### Communication and Cultural Aspects

The impact of knowledge on acceptance has been supported by the workshops and expert meetings. These participation processes (especially the workshops) reduced the complexity of the subject and improved the state of information, giving a push to the common motivation to install test projects in the research regions. Different experiences and reactions from participants of workshops and statements from experts showed that acceptance and knowledge interrelate partly with cultural factors. This finding had an influence on further interactions (talks, workshops and interviews) with regional actors in the two countries. It is important that cultural background is taken into consideration when devising communication methods related to technology and design.

### *2.1.2 Role of Design and Aesthetic Influences*

The appearance of PV modules might be an important acceptability factor as design influences social acceptance. Therefore attitudes concerning aesthetic aspects of the expert group and of the public were gathered and analysed in both countries.

#### Reactions to Standard Modules

In order to receive information on perceptions concerning standard solar modules, we asked the residents for their opinion about aesthetic aspects. Characteristic features of conventional modules are dark colours (black/blue), a shining surface with or without visible metal conductors and a rectangular and uniform shape.

Only a minority of respondents considered the existing standard modules to be good looking and the large majority stated that they found the look of PV modules to be either neutral or "not interfering". Precisely,

- 62% of Italian respondents considered PV modules to be "not very aesthetic", while
- 71% of the German respondents found them "neutral".

This underlines the importance of aesthetics and indicates that they have so far been underestimated. It also shows remarkable country-specific differences in the case of aesthetic acceptance of standard PV modules.

### Design Variability related to other Factors

To explore the significance of design alternatives for PV modules, the expert groups and the local population were asked to rate the most important factors for PV distribution. Two choices were to be evaluated: The first statement expressed that lowering costs is the key to increasing PV distribution, whereas the second one argued that only the development of more appealing panel designs would increase distribution.

Our expert groups agreed with a majority of about two-thirds in both countries that the design-variability of PV modules is an important influencing factor for the distribution of PV. The results of the population survey show that the respondents in both countries agree with a large majority, and agree "strongly" with a rate of about 50% that design aspects are the most important distribution factor (cp. Figure 3).

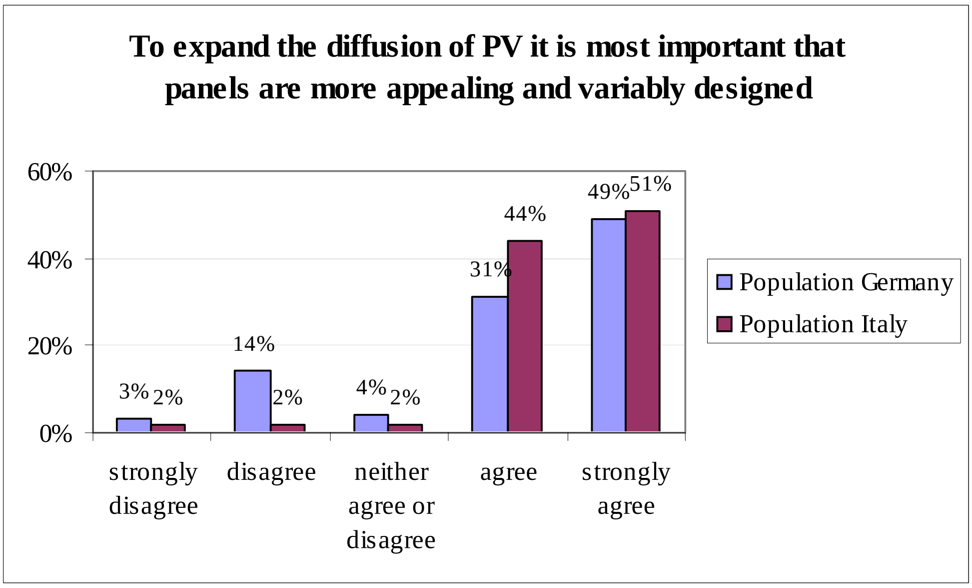


*Figure 3: Residents' view concerning the importance of more appealing and variably designed panels*

### PV on Protected Buildings

Residents and expert groups were asked about their opinions of and attitudes towards the introduction of PV in tourist areas with a high degree of monumental and environmental protection.

Both expert groups in Germany and Italy were mostly optimistic concerning the use of PV in protected areas and on (or at) monumental protected buildings.

The majority of the citizens surveyed also expressed support for this idea, as *Figure 4* shows. A control question formulated the other way round confirmed that there is no majority for a strict ban of PV in such areas or on such buildings. Again, country-specific differences can be identified: The German respondents agreed significantly stronger than the Italian respondents. In total, a clear majority in both countries agree to the instillation of PV on/at historical monuments if it is done properly.

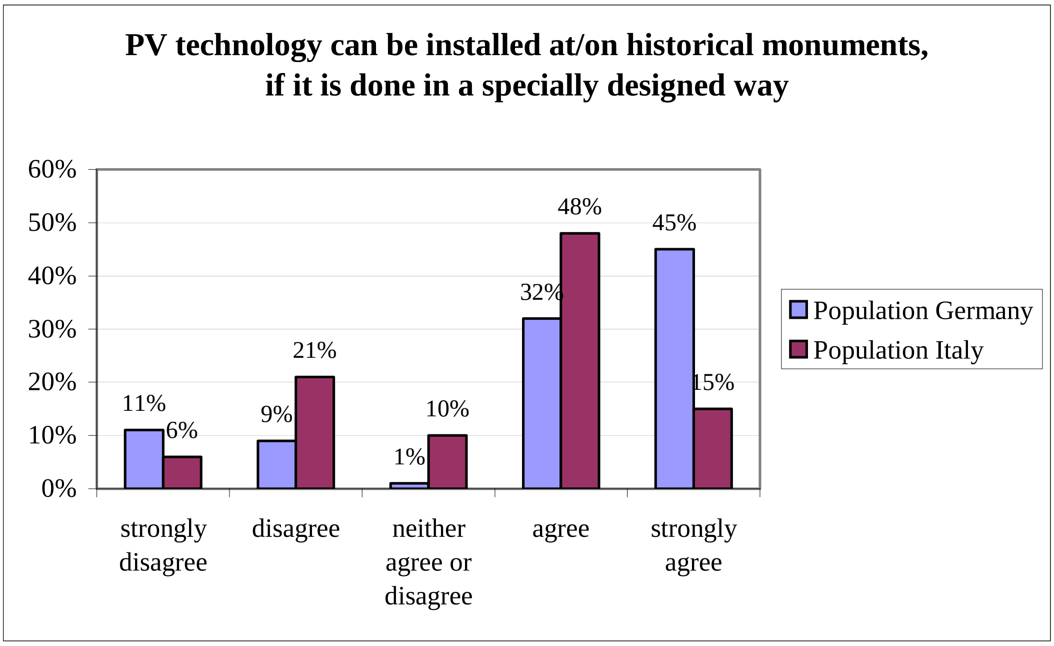


*Figure 4: Residents' agreement to the installation of specially designed PV at/on historical monuments*

### *2.1.3 PV in Protected Tourist Areas*

A great advantage of using PV technologies in protected tourist areas is the possibility of creating multiplier effects and an increased acceptance of this technology. The study explores various aspects concerning possibilities, conditions and barriers.

**Barriers in Protected Tourist Areas**

A central problem lies in the present general exclusion of solar technology at historical monuments – in Italy but also in Germany. In the case of buildings under monumental protection, PV systems always need a license from authorities. And during our own experiences in both countries we witnessed in cases a very restrictive licensing practice. Exceptions are sometimes possible, depending on the interests and attitudes of local authorities, and also if influential promoters from a level above support the project. On the one hand, the situation in Italy seems to be more difficult due to a higher number of protected buildings and the existence of some very large areas under protection. On the other hand, we experienced comparatively more individual support and more willingness to find creative ways to proceed with the licensing process. This may hint at another cultural difference, but is of course far away from being a representative finding.

**Multiplier Effects in Tourist Areas**

Nearly all experts and also a broad majority of the surveyed citizens agree to the notion that tourist areas can be well-suited to increase public awareness of PV technology (cp. *Figure 5*). The figures comply with the thesis that tourist regions are especially suitable to create multiplier effects and increase the distribution of PV technology. Hence, it would be reasonable to establish more PV demonstration projects ("models") in these sensitive regions.

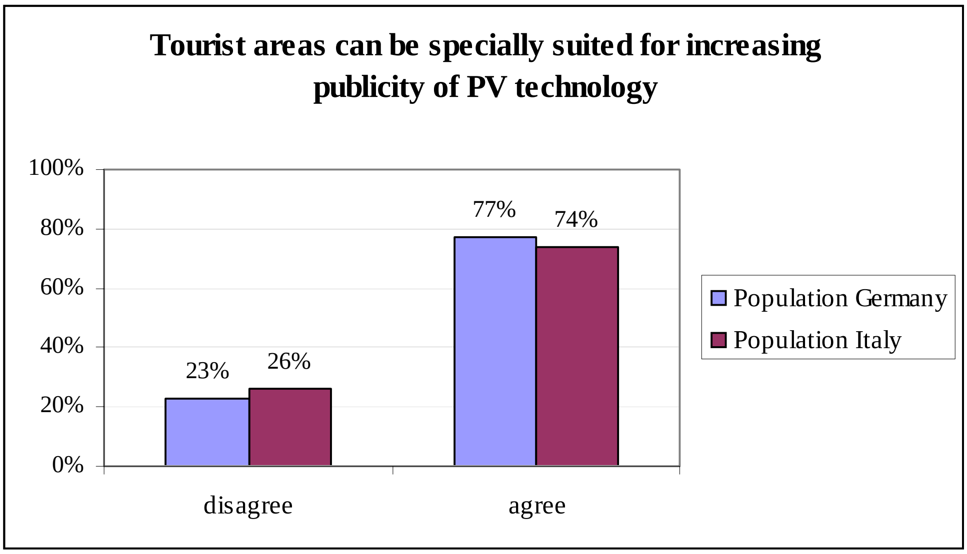


*Figure 5: Residents' view concerning tourist areas' aptitude to increase publicity of PV technology*

### Local Policy Aspects

How do residents asses the promotion and funding of PV installations in their own communities? An overwhelming majority of residents in Germany and Italy favour local support (see figure 6) as well as an increased use of PV modules by the local authorities themselves. The strong approval in this matter is a further sign for the positive attitude of the population towards PV technology.

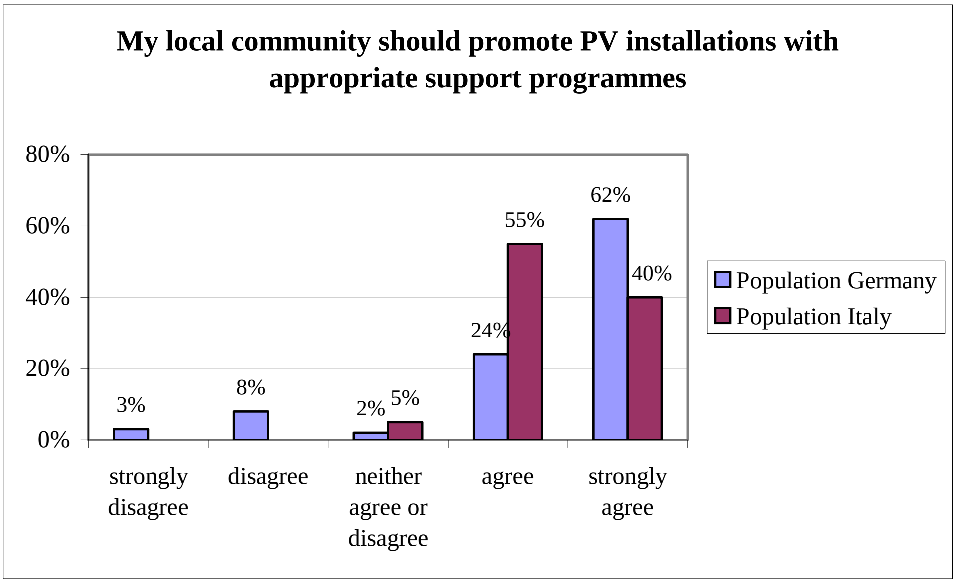


*Figure 6: Residents' view concerning their communities' promotion of PV installations with appropriate support programmes*

In both countries more than 40% of the population could imagine the financing of PV plants connected to tourist sites at least in part by instruments like tourist taxes. Large majorities in both countries would also welcome their local community to build or support more solar plants to set an example for the residents.

Finally (only in Germany), we asked for the interest for personally using solar technology. In the German region, 14% of all respondents were interested in solar collectors and another 11% in PV plants. Compared to the percentage of actual owners of such plants, these numbers indicate at an enormous potential for regional markets. This potential should be addressed by local policy makers and local companies.

### *2.1.4 Project Activities and Local Acceptance*

Besides producing research results, the project itself had an impact on local acceptance through the activities it created. Workshops, several expert meetings, and the information provided by press conferences and supplementary interviews were events that raised public awareness. In addition, the networking between participants led to further processes during the stages of planning and realising of the demonstration projects.

The impacts of the project’s activities could not be measured in detail, but the awareness of the PVACCEPT project itself was tested within the surveys: about 12% of both the Italian and the German respondents stated that they had already heard of the project (cp. Figure 7).

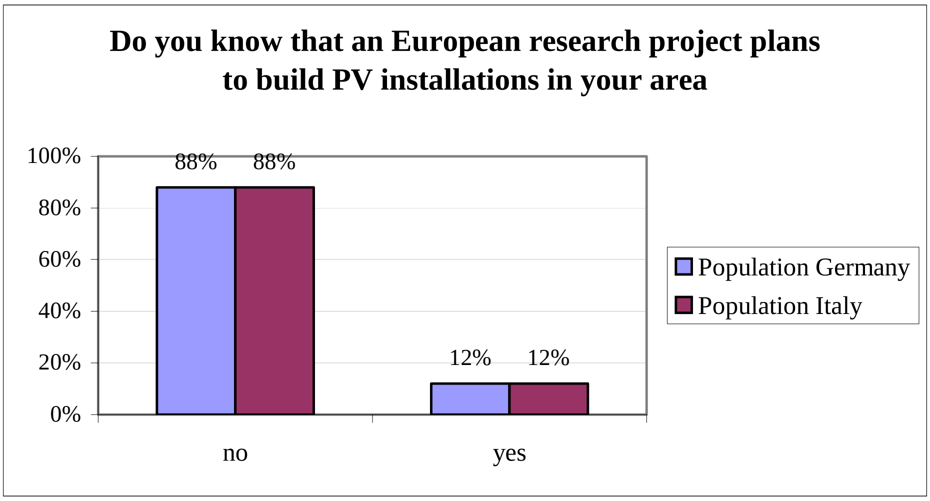


*Figure 7: Resident’s awareness of the plan of PVACCEPT to install PV plants in their area*

## 2.2 Results “Ex Post” Study

The centre of attention in the second part of the acceptability study turned towards architects, specific problems in tourist areas with protected areas and the development and results of the built demonstration objects within PVACCEPT.

As architects represent important intermediaries between the PV industry and private, commercial and public house owners, they can promote or hinder the depoloyment of photovoltaics. The knowledge and acceptance of PV from architects plays an important role as well as influences acceptability among other important players such as administrations and the general public. Architects can help to improve the flow of PV related information. Moreover they can contribute to the creation of aesthetically attractive PV installations and they have an insight into the needs of the owners of buildings, as well as their attitudes and expectations concerning PV design. Compared to craftsmen, architects have been mostly neglected by public campaigns and scientific research up to now (Duscha 2002). As a result, we decided to focus on the role, knowledge, attitudes and needs of architects concerning acceptance and distribution of solar technology through a number of interviews in Germany and Italy. The empirical results are mainly filed into the two categories: knowledge/education and attitudes towards the role of design.

A second empirical part of the study focused on administrative problems for innovative technologies like photovoltaics in protected areas and on acceptability problems in associated administrations. Several interviews with local officials but also with architects were carried out concerning these problems; some of the bodies and architects contributed to the evaluation of the PVACCEPT projects.

Lastly, interviews with local population, tourists and architects were conducted concerning the evaluation of the realized PV demonstration objects as well as some further design examples produced by the architects of PVACCEPT.

### *2.2.1 Knowledge, Attitudes and Role of Architects*

**Knowledge and Education**

The majority of the interviewed architects have had personal experiences with PV. While the Italian architects have mostly had contact with photovoltaics during the planning stages for new buildings, their German colleagues have applied PV to both existing and new buildings.

Most of the interviewees in both countries – younger as well as more experienced architects – stated to have gained their knowledge on PV mainly through private training. Also, most of the architects in both countries complained about significant shortcomings in the professional education of architects concerning solar technologies. The majority of the responding Italian and German architects would like to know more about and see more (successful) projects in the field of solar architecture.

Gaps in specific knowledge about solar technologies had also been shown by an Austrian survey. Gerhard Hold concludes that Austrian architects, “do not have the necessary know-how for developing energy optimised concepts of buildings which include PV technology” (Hold 2002). The level of education of architects concerning solar technology seems to be a problem in European countries, independent of the distribution rate of such technology.

In the end, all of the responding Italian architects showed a high level of interest for additional training, while half of the German respondents expressed interest.

**Attitudes towards PV Design and Integration**

The architects’ perception of standard solar modules (dark blue or black colours and uniform shapes) and their design preferences were found to be country-specific as well. The Italian architects expressed a much more negative view on the look of standard solar modules than their German colleagues. In addition, German architects favoured PV installations on the facades of buildings, while their Italian colleagues prefer them on roofs (see figures 8 and 9).

While the different results are significant, it remains unclear as to what kind of PV experiences have led to the views expressed by the respondents.

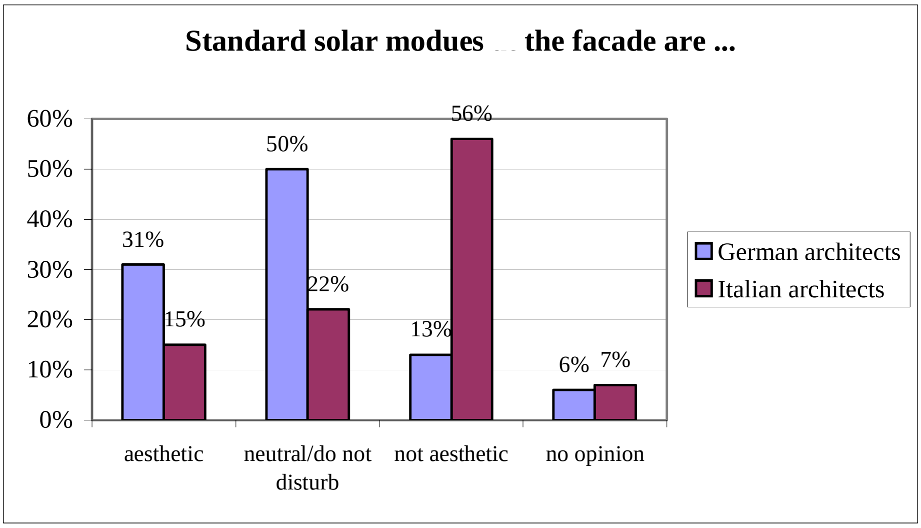


*Figure 8: Architects' attitude concerning standard solar modules on the facade*

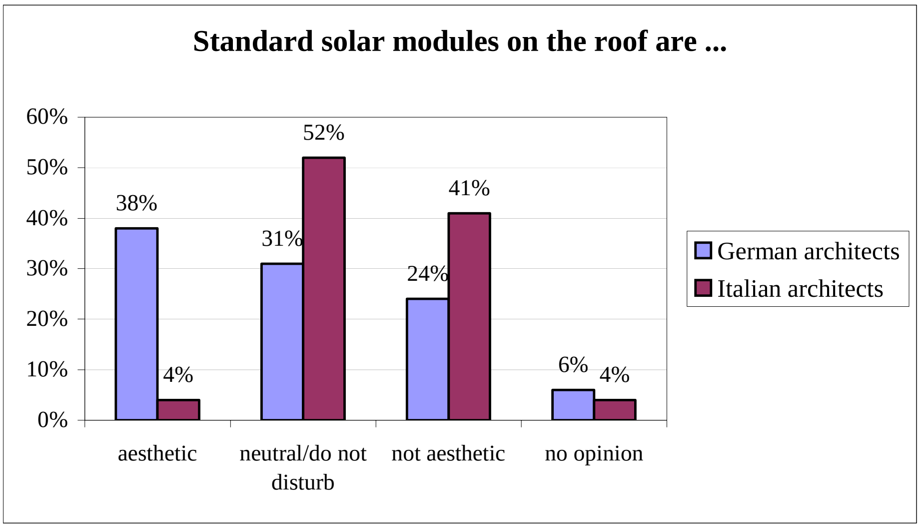


*Figure 9: Architects' attitude concerning standard solar modules on the roof*

In a next question design and efficiency were rated by the respondents in order to investigate the relevance and significance of the two factors. Again, the answers differ significantly between the two countries. On the one hand, 70% of the asked Italian architects considered the development of new designs to be the central aspect for the development of innovative PV modules and on the other hand, almost the same percentage of their German colleagues regard the increase of efficiency to be more important (cp. Figure 10). Nevertheless, when asked about this topic in another question, most architects in both countries ranked cost reduction as the most important issue in order to improve the acceptance of PV technology.

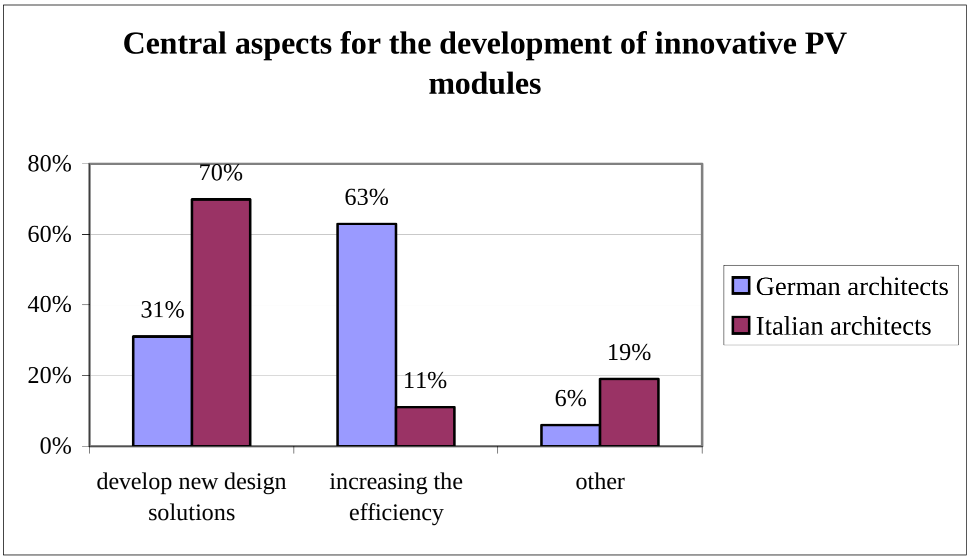


*Figure 10: Architects' view concerning central aspects for the development of innovative PV modules*

The next figure shows the respondents' answers when asked to decide on whether the installation of PV at or on protected monuments should be realized "in any case" or only if it was designed in a suitable way. A large majority of the inquired Italian architects supported the statement to install PV "in any case", arguing for the most part that PV technology is environmentally-friendly. The views of their German colleagues differ significantly: about half of them would like to see PV on historical monuments only if integrated "in a suitable way" (cp. Figure 11).

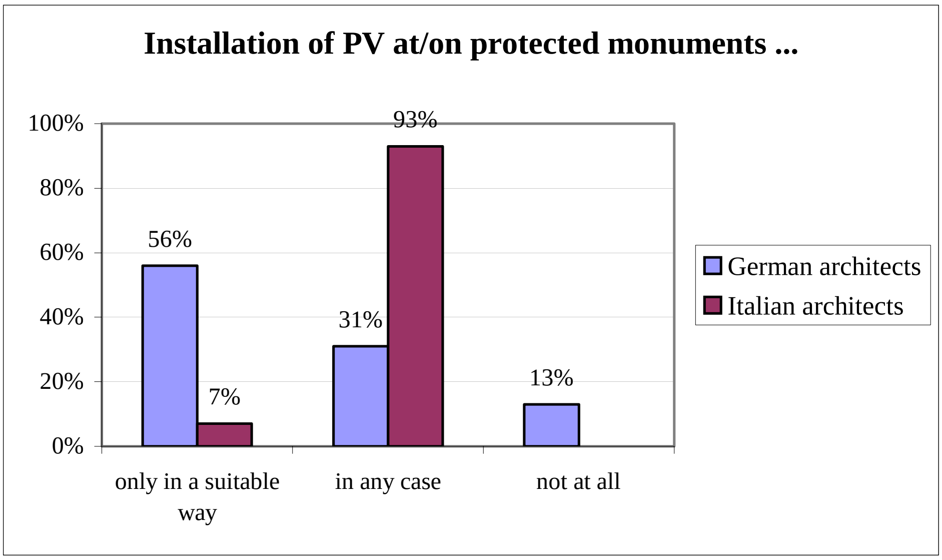


*Figure 11: Architects' view on the installation of PV at/on protected monuments*

Architects from both countries anticipate significant market potential for innovative PV modules in different shapes, colours etc. While nearly all Italian architects see a future market even for conventional photovoltaic applications, most of their German colleagues see the potential of such modules limited to a market niche. This different assessment seems to match the attitudes presented above.

### *2.2.2 Administration and Authorisation Processes*

The present ban on PV modules in protected areas affects many large and well located areas. In some areas this ban is general; in others the authorities determine success or failure strongly depending on the knowledge and goodwill of administrators. German and Italian architects and representatives from administration were questioned on this topic.

**Administrative Barriers to PV**

According to the majority of architects interviewed, public authorities dealing with historical monuments seem to do their job very strictly and precise: they have a general problem when confronted with the idea of changes of protected buildings and areas. Departments of monumental protection are perceived as a “limiting force in practise, which require(s) a lot of persuasion” (citation from interviewed architect), even when restoration or renovation is needed.

On top of this general attitude one general formal or regulative obstacle to PV is that in many regions in Germany and Italy a prohibition of the use of this technology exists: either there is a general direction for larger protected areas (like historical centres) or there is a general order from a regional/superior authority to the local authority of monumental protection to prohibit the application. An example of the latter case can be found in Baden-Württemberg, where regional authority gave such an order to its subordinated bodies.[7]

The next problem the interviewed architects mentioned occurs when a project is in an authorisation process. At that stage many of them reported frequently about very long and complex authorisation processes in both countries. This has on the one hand to do with the general aspects mentioned above and with the complex frameworks and regulations; on the other hand, it seems to be a matter of missing knowledge (in addition to attitude).

The interviewed architects and even the asked people of authorities themselves think that regulators lack knowledge about PV and have prejudices concerning the appearance of solar modules. In fact, some of the public servants are generally very skeptical of PV on protected buildings. They argue that, “there are enough other, non-protected buildings where PV plants could be installed,”and deny the general need for PV installations on protected buildings. Other representatives of authorities more open for solar architecture in general said that they would moderately support PV if it is installed at “architectural simple old buildings.“ A general impression of the interviewed authority representatives was that PV modules have an unaesthetic design. In their view PV modules have “smooth, reflecting surfaces”, “a special dark colour” and “enormous sizes” (aspects mentioned by some of the respondents). Newer PV developments like other module and cell types and architectural integration besides the application of a plant on top of a roof were not known. Prejudices and missing knowledge like these result in formal orders like mentioned above. The respondents confirmed nearly all that besides the lack of information good-practise examples are missing and that those could help to increase both knowledge and acceptance. More good examples could “build a bridge

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7 Other cases were described by several interviewees, but it was not possible to gain further official documents as most of them have the character of internal orders.

to a more positive routine", like one interviewee said. To decrease the lack of knowledge and proper information, appropriate education programmes for the authorities were demanded.

The experiences of the PVACCEPT project support the qualitative results of the interviews. The responsible architects of PVACCEPT (UdK Berlin) encountered positive and negative attitudes regarding the administrative decision-making levels, especially on the side of the involved monument protection authorities. The visible results of the support by some administrations are, on the one hand, the four built demonstration objects of PVACCEPT. The result of restrictive attitudes, lack of knowledge and interest on the other hand could be recognised in the original research region on the island of Rügen (Mecklenburg-Vorpommern), where no object could be realised in the end (alternatively an object in Marbach, Baden-Württemberg could be realised)

With regard to experiences of the interviewees and the PVACCEPT project itself, it was crucial to start communication with local authorities early, provide important information about the project from the beginning and keep them involved. This was a crucial strategy for the successful implementation of three PV projects in Liguria, Italy. Here the involvement of relevant local key persons, the early involvement of monument protection authorities and the existence of a regional territory framework plan were relevant success factors.

### Instruments supporting the Distribution of PV

The respondents were additionally asked about their favorite political, financial, and administrative instruments to promote the distribution of PV. Specifically, two main instruments to enhance the general distribution of PV were mentioned:

- Binding obligations – supporting PV and concerning a duty to build PV systems on new buildings.
- Financial incentives - mainly regarding the German model and the German Renewable-Energies Act that has a special feed-in tariff for PV and an additional special bonus (5 Euro-Cent) for PV plants at facades (see version of the German EEG 2004).[8]

With regard to implementation in protected areas or on/at protected buildings, more flexible regulations concerning PV are necessary to simplify and to shorten the process.

A clear outcome of the Italian workshop is the importance of a clear framework for PV programs. This is exemplified with the case of the Regione Liguria, which approved in 2003 its Framework Plan for the territory and landscape (Piano Territoriale di Coordinamento Paesistico). Moreover, local environmental action plans (e.g. the local Agenda 21 in La Spezia) can be further facilitating factors.

[8] Italy plans to establish a comparable instrument like the German "EEG", a feed-in tariff only for PV, in the summer of 2005. For the other renewable energies, other instruments like quotas and certificate markets are being discussed.

### 2.2.3 Review of designed PV Demonstration Objects

To gauge reactions of planned PVACCEPT drafts, simulations, and realised PV demonstration projects, German and Italian architects were asked for their reviews of a selection of design examples for PV installations.[9] In addition, tourists and local inhabitants of the regions where PV demonstration objects were built were asked about their impressions of the installations.

**Architects' Review of Designed PV Installations**

German and Italian architects both gave positive reactions to pictures of the four implemented projects and also two drafted projects:

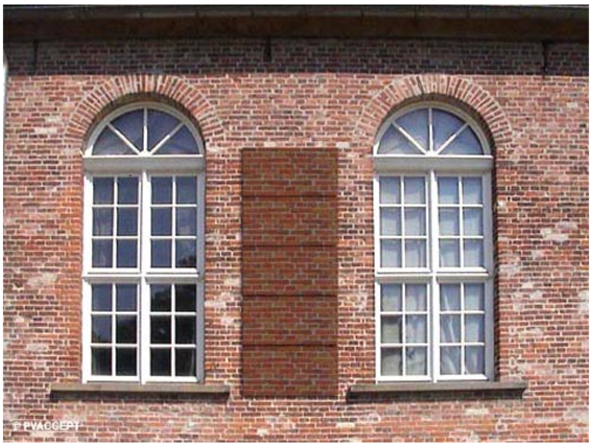
In Germany, five out of the six presented projects were seen as interesting (category "should be repeated"). Only one project, the solar tree in Putbus (see picture 1) that was not built in the end, got more negative than positive evaluations. The most positive evaluated project was Bocca di Magra (see picture 2) followed by the project Marstall (not carried out, see picture 3), La Spezia (see picture 4), Porto Venere (see picture 5) and the city wall in Marbach (see picture 6).

Two thirds of the Italian architects stated that the projects are interesting and should be repeated. However, only 27% see the projects as aesthetically appealing.


*Picture 1: „Solar tree" in Putbus / Germany; protected park area; not realized*

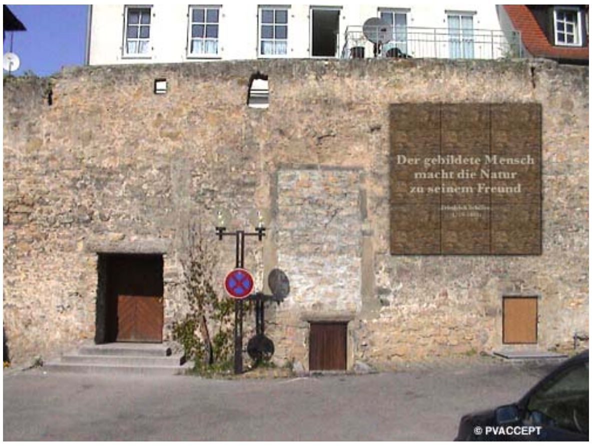

*Picture 2: Solar pergola in Bocca di Magra / Italy; realized as demonstration project with modified design*

[9] A larger selection of examples can be seen in "Solardesign – Photovoltaics for Old Buildings", Hermannsdörfer/Rüb (2005): Urban Space, Landscapes; Berlin.

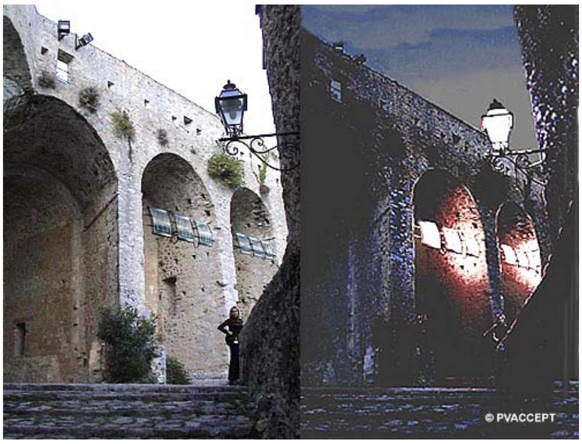


*Picture 3: PV facade installation in Putbus / Germany; building under monument protection; not realized*


*Picture 4: Solar information board in La Spezia / Italy; listed monument; realized PV demonstration project*




*Picture 5: Solar Schiller quotation plate in Marbach a. N., Germany; historical town wall; realized PV demonstration project*




*Picture 6: "Solar flags" in Porto Venere, Italy; listed monument; realized PV demonstration project*

**Population Feedback on PV Demonstration Projects**

After implementing the solar projects at the four test sites, surveys were carried out in Bocca di Magra, La Spezia Porto Venere, Italy and in Marbach, Germany.[10] Tourists and inhabitants reflected their impressions and attitudes concerning the applied PV installations and two more drafts (the same as in the architects case, see pictures above) but were asked also some general questions on the subject to get a deeper understanding of their attitudes and evaluations.

The feedback showed in general that all projects reached a high acceptance in terms of positive reactions to the objects. Only two samples had smaller support, and the results show clear directions. The surveys contained six questions with the following results:

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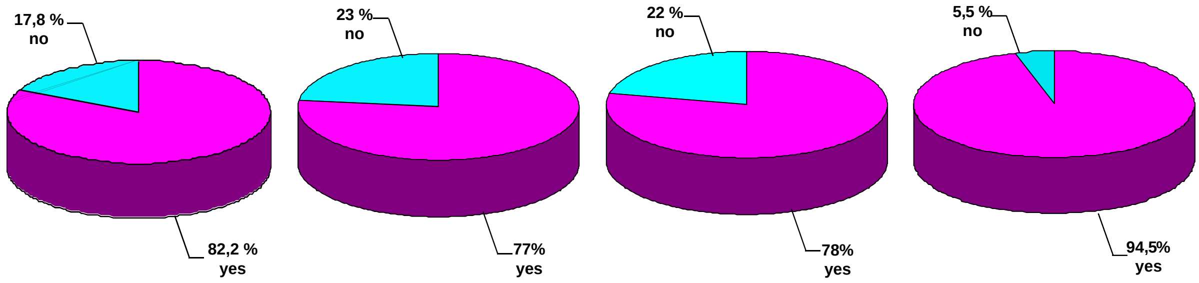
[10] The enquiry of tourists and inhabitants was carried out from August to December 2004 by UdK Berlin (coordination: Ingrid Hermannsdörfer) in cooperation with the four communities. In total 190 people answered the questionnaires.

*1. Have you ever seen a photovoltaic installation or module (on a building, in a shop, on a picture, in a newspaper, in other information material?)*

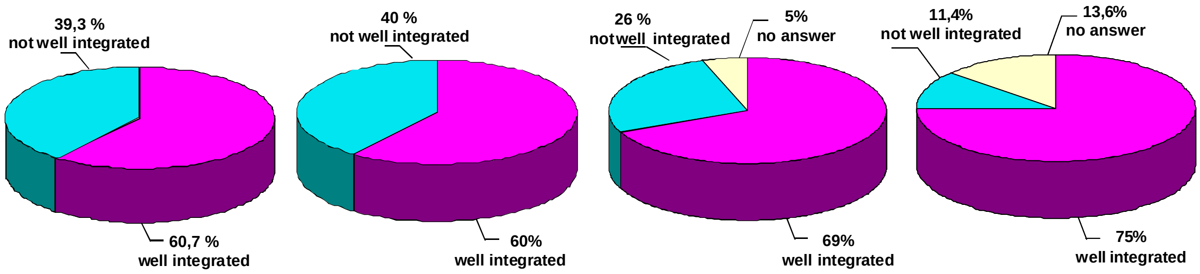
In Germany nearly all respondents (94.5%) answered positively whereas in Italy the rate was between 77 and 82 %, confirming once again the higher level of knowledge about solar technology in Germany. Nevertheless the level seems to increase slowly in Italy (compared to results of the first phase of the project).




Porto Venere La Spezia Bocca di Magra Marbach

*2. If yes, what did you think about the aesthetic appearance of these modules?*

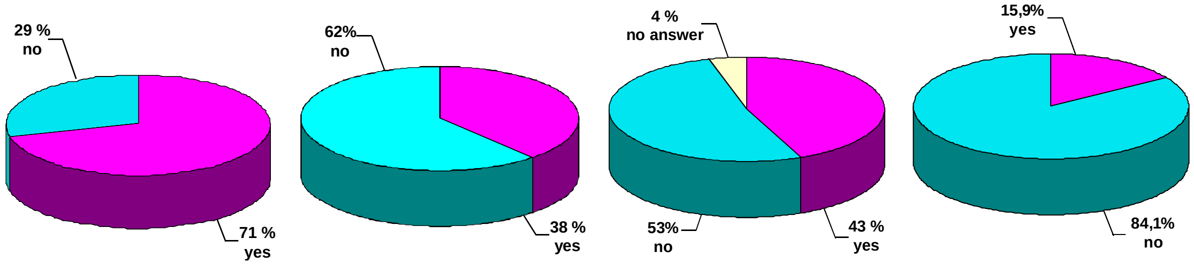
The second question focused on the acceptability of standard modules and the general design. This was compared to the acceptability of the innovative PVACCEPT designs in another question. Only those questionnaires were considered that had answered the first question positively. About 40% of the Italian interviewees regarded standard installations, which they had seen, as “badly integrated”. In Germany more interviewees than in Italy considered integration positive (75%).




Porto Venere La Spezia Bocca di Magra Marbach

*3. When you first saw the installation, did you recognize it as a power generating installation?*

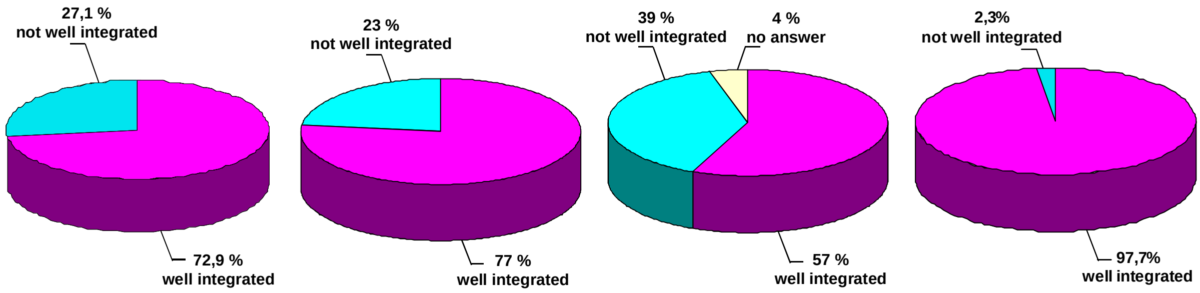
This question focused on the concrete assessment of the realised PVACCEPT objects. The answers illustrate that the samples were not easily recognized as photovoltaic modules. The most successful installations in hiding the primary function were the information board at the castle in La Spezia, Italy and the Schiller quotation plate in Marbach am Neckar, Germany. The design method and module type are identical at these two locations. The “solar flag” installation in the courtyard of the castle in Porto Venere had the highest recognition rate with 71% due to its technical “look” and the visible power cables. This was followed by the pergolas in Bocca di Magra with 43%.




Porto Venere La Spezia Bocca di Magra Marbach

*4. What do you think about the design of this installation?*

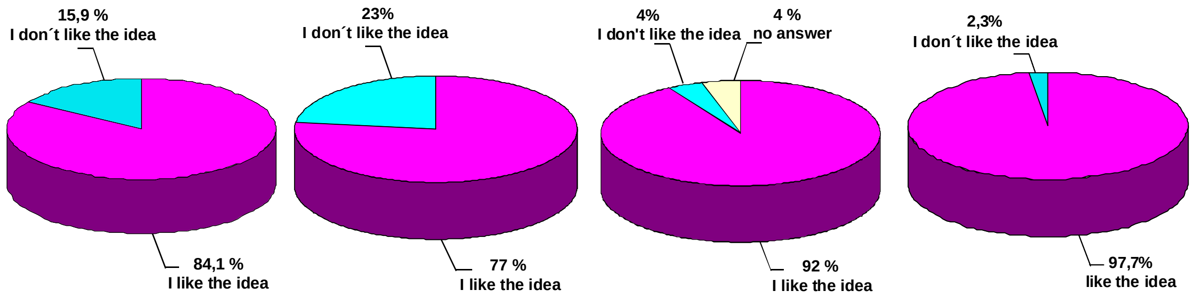
This question was meant to determine the acceptability of the specific object design, especially its integration into the building and its surroundings. The Schiller quotation plate in Marbach achieved the best impression in terms of integration with an overwhelming majority of over 97%. The installations in Porto Venere and La Spezia were classified well integrated by a smaller majority of 75%. The pergolas in Bocca di Magra received the lowest approval with about 60%.[11]




Porto Venere La Spezia Bocca di Magra Marbach

*5. What do you think about the idea to design solar modules in such a way?*

Giving solar modules an innovative look by new designs lends to even more acceptance than their integration levels ranging from 77% to 97.7 %. The figures exceed positive answers of



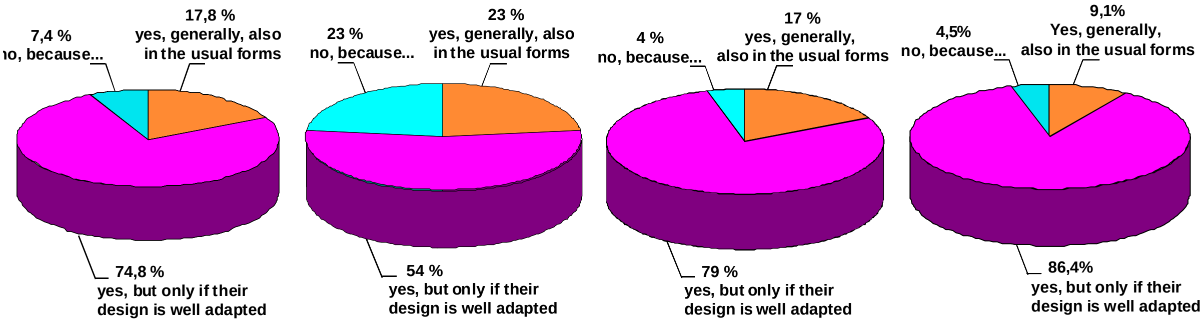

the previous question on appropriate integration in both countries.

Porto Venere La Spezia Bocca di Magra Marbach

11 Due to some additional talks it seemed as if the answers concerning the solar pergolas in Bocca di Magra reflected the opinion on the complete installation, including the colours in which the community painted the structures. The acceptance rate for the modules themselves is considerably higher, as shown by the next answer.

*6. Do you think that solar powered systems should also be installed on historical buildings?*

A majority of interviewees, ranging from 54% to 79%, can imagine such modern technologies on monuments if the design is well adapted to the site. A smaller percentage, 9% to 23%, voted in favour of standard modules on such buildings. This reflects the results from the first part of the acceptability study (ex-ante) in the initial phase of the PVACCEPT project. Only a relatively small number of interviewees (4% - 23%) completely denied the application of PV.




Porto Venere La Spezia Bocca di Magra Marbach

The main findings of the enquiry of tourists and inhabitants can be summarized as follows:

- The general acceptance (measured by positive reactions) of the innovative PV design of the PV demonstration objects is very high in both countries; in the case of Marbach am Neckar, Germany, it was close to 100%.
- A significant number of respondents judge the look of standard modules as “not aesthetic”.
- Concerning integration, modules which are easily recognised (e.g. wiring in Porto Venere) are less accepted, especially when installed at monuments.
- Most people support the idea of modules on monuments if the design is individually adapted, and only a small minority is against the application of PV.

# 3 Final Conclusions and Recommendations

The following final conclusions and recommendations result from the empirical material gained within the PVACCEPT project and refer to the main aims of the project. At the end of this chapter the need for further research is described.

## 3.1 Knowledge about PV and Need for Further Education

Results of the study clearly show that knowledge is an important acceptance factor for the distribution of a new technology like PV. A second key finding is that the current level of information and knowledge is low and differs between the two investigated countries and even within the stakeholder or target groups. Therefore, the need for education to increase acceptability and distribution of this technology is still high. Education should encompass the general function, techniques, system aspects, design and innovative possibilities of PV systems and should be focused on groups such as the general population, architects, SMEs and relevant authorities.

**General Knowledge of Population**

The surveys executed in the research regions showed a limited general knowledge about PV and national differences were observed. People in Germany are slightly more informed than people in Italy, which may correlate with the different distribution rates. But still, a notable group of more than 60% is not familiar with the fundamental differences between solar power and solar heat. Therefore it is important to increase education about solar technologies and renewable energies in general. This ranges from a basic level to the specialised practice level, as well as in a tailored manner for different social or target groups:

- ⇨ Increase base knowledge in *schools* through mandatory courses on solar technologies and renewable energies focusing on theory and practice. This should be part of every school's curriculum including higher education centres. To accomplish this, *school teachers* need to be educated on renewable energies.

- ⇨ Special *information campaigns* should be created (i.e. TV-spots, campaigns by public services, leaflets) to reach population on a broader scale, working with comprehensible slogans and understandable information. Different levels of knowledge as well as cultural differences in different regions and countries have to be taken into account.

- ⇨ *Detailed information* about PV could be transferred via *consulting services* or by using other contacts to customers. Consulting services could help to educate about energy efficiency of buildings and reducing energy consumption of a building (e.g. heating system) like it is done by energy agencies, public services or professional engineering offices. In Italy a regulative framework has existed since the summer of 2004; this framework provides significant incentives to raise energy efficiency and consider solar, thermal and PV systems. Additionally, the promotion Energy Service Companies (ESCOs) is part of this framework, like it is discussed also at the European Level by the European Commission (discussions about Energy End-Use Efficiency and Energy Services Directive). ESCOs could play an important role in the future as a multiplier of energy efficiency and also renewable energy knowledge.

**Knowledge and Education of Architects, Engineers and SMEs[12]**

Important intermediaries like architects, designers, engineers but also small and medium-sized companies in the building and energy sector are important actors to promote and implement solar technologies. Moreover they are able to create multiplier effects concerning the level of knowledge within population.

As interviews with architects showed, it is often the architects themselves and not their clients that initiate the implementation of a PV system into a building. On the other hand most of the interviewed architects expressed a high demand for basic and further education pertaining to solar technologies and new developments. In Italy the demand was higher and more general than in Germany; again this might be related to the existing distribution and information rate. With regard to this we propose the following actions:

- ⇨ Improved knowledge of intermediaries like architects, craftsmen, designers, and engineers concerning PV technology, its design possibilities, and subsidy programmes is absolutely necessary. The knowledge about PV as "energy producing material" should be integrated into the *general and secondary education* of architects, relevant actors and appropriate learning and study programmes. For instance, German schools offer special solar training for craftsmen called "Solarteur", which focuses on the benefits of renewable energy, especially solar technology. The Donau-Universität in Krems, Austria, offers a postgraduate degree in solar architecture.

- ⇨ Such educational programmes and courses need to be tailored to regional and national differences. For example, between Germany and Italy regarding the different architectural contexts and design developments. In addition, there is a need for good examples of solar architecture to show the different options and several design possibilities in different surroundings. This is a crucial aspect for the acceptability within the design community.

- ⇨ Specialised internet platforms have to be developed to provide easily accessible information at a general and specific level including offers, information, links etc. One example for such a specific "solar" platform is the German homepage www.solarintegration.de; this site is especially made for architects, providing information about the technology, subsidies, architectural examples etc.

- ⇨ SMEs remain important clients for solar systems; in addition, these companies working in the building and energy sector are also important multipliers and suppliers. As shown by the remarkable interest of firms that applied to the training offered by the PVACCEPT

[12] SMEs stands for Small and Medium Sized Enterprises.

project, SMEs are an important target group that needs to be addressed specifically due to their limited knowledge and lack of resources.[13]

In particular, SMEs need easy access to specific information about PV. This requires suitable information tools and training activities that contain information on technologies, applications, and governmental grants. It is important to include relevant links and tools, information in their native language, applications for non-experts, online solutions and easy access to consulting institutions.[14] To widen the spectrum of interested firms it might be also helpful to combine consultation services with renewable energy and energy efficiency (see above).

**Knowledge about Subsidy Programmes**

Knowledge about solar technology concerning costs, subsidy programmes and financial mechanisms was expected to be lower than the general understanding of solar technology. Those interviewed in both countries have low and incomplete knowledge about their regional and national subsidy programmes for PV systems. Again, the Germans were better informed than their Italian neighbours, as the programme participation and technology distribution rate is higher in Germany.

One problem is that information on subsidy programmes is normally quite complex due to the construction of the instrument itself and/or the need to combine different mechanisms to make it economically feasible. For example, in Germany the 100,000 roof-programme could be combined with the PV tariff granted by the Renewable Energies Act.

A second problem is that the construction and conditions of such financial mechanisms often change and are adapted or rearranged due to political changes or changes in system costs.

Given this background we recommend the following:

- ⇨ Group specific information tools and campaigns should be developed with financial support from the national to the local level in mind.
- ⇨ These tools need to be both specific (expert language and additional information) and flexible (regular financial updates). Such information and tools can be combined with the information platforms mentioned above.

**Knowledge of Public Administrators**

Local and national public administrators from monumental or environmental protection authorities can play a role in the distribution of PV. This is applicable to all buildings under monumental protection and also areas where PV is prohibited. The results of the study and the experiences from the project showed that these decision-making bodies often lack specific knowledge about solar and PV systems, and that prejudices and general instructions

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[13] These trainings were executed by professional PVACCEPT partners on the local level in Germany and Italy.

[14] In this context the dissemination tools developed for PVACCEPT (website, design handbook, itinerant exhibition) are also helpful instruments for future use.

"from levels above" are obstacles. As we have seen, these actors can be both positive multipliers as well as bottlenecks against the application of PV systems.

⇨ There is a strong need for further education for public administrators concerning new developments of PV technology. In addition, the regulative framework has to be changed or adapted to allow for proper individual assessment of PV projects. (see also section 3.5)

## 3.2 The Role of Design as important Factor for Acceptability and Distribution of PV

The acceptability study found that the role of design of PV modules has been underestimated. The aesthetic look of PV modules influences the social acceptance of PV technology. Innovatively designed PV modules, adapted to the specific aesthetic requirements of the installation site, can help to improve acceptance and therefore the distribution of PV. In a few words: *Design matters!*

Both German and Italian respondents considered innovatively designed modules as crucial for building-integrated solutions. The Italians especially showed great interest and sympathy for new PV designs. Overall, it is important to develop adaptable cells and modules to achieve successful implementation. Like some of the interviewed architects noted, PV should blend into existing structures and attract as little attention as possible. Therefore, different design options have to be developed at affordable market prices.

While the Italian architects generally believe that a large market potential for customised solar products exists, the German architects consider the greatest potential to be in the high-price segment.

The overall response from inhabitants, tourists, and architects to the four customised PV installations was very positive. While 40% of the interviewed Italians and 25% of the Germans considered standard PV installations poorly integrated and aesthetically unappealing, the majority of respondents in both countries (up to 98% in Marbach, Germany) appreciated the installations. In some examples, the PV plant itself and also its function went unnoticed by observers. A majority of interviewees said they could imagine PV installations on monuments, if the design is well planned.

In regard to the role of design, the following recommendations are made:

⇨ The implementation of successful PV systems and an increase in the promotion of PV projects is important a way to increase awareness and acceptance. This should be taken into account by local, national and European support programmes; the promotion of further projects showing new and improved integrated design options should be continued and expanded.

⇨ The knowledge about new design developments, architectural aesthetics and possibilities of PV as material, building component and power plant has to be included into common education (schools) and especially into professional education of architects and craftsmen.

- ⇨ Because customised PV modules are quite new, there exists no established market for these products. Therefore marketing has to be developed and funded to open up new markets. Approaches like “strategic niche management” would be useful as mechanism to create new markets.[15] This approach focuses on strategic implementation and evaluation of new technologies that potentially solve social problems but do not establish on the market without any support. Especially young technologies often need those niches (see Truffer 2004).

  Slogans like “PV instead of marble” or “power instead of marble” (taken from the name of a conference in Herne, Germany, november 2003) could be relevant in marketing campaigns for façades, as a PV facade can have a noble look and earn money or save energy at the same time. PV facades can be prestigious symbols for corporate buildings or headquarters (for example, at PV producing firms). The idea of PVACCEPT also opens up opportunities to study the integration of PV in historical buildings. Innovative concepts for large historical centres like in Italy and Germany could open up markets for customised PV installations.

## 3.3 Economic Factors and Instruments

Although interviewees perceive design as an essential acceptability factor, they still see the high costs of PV as the main obstacle to implementation. Appropriate subsidies are desired by most of the respondents to overcome the gap between willingness and real implementation of PV objects, thus fostering the distribution of PV. The surveys asked questions about economic factors such as favourable promotion instruments and mechanisms.

The German tariff-system (“Erneuerbare Energien Gesetz”, Renewable Energy Act) was positively received by the respondents in terms of a successful distribution method (see Hirschl et al. 2002, Hirschl 2002 and 2004).[16] In Spain similar financial incentives for solar power generation exist. Together with other promoting framework conditions, Spain could soon be the second leading PV market in Europe. In the summer of 2005, Italy shifted from investment funding related to the Italian Roof Programme (used in 2001-2004) to a feed-in law with similar utility rates for each kWh produced by PV.[17] Even though many other coun-

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[15] The project "Strategic Niche Management as a Tool for Transition to a Sustainable Transport System" (1996 – 1999) executed by the European Commission already did some research on this new instrument within the field of mobility.

[16] The renewable energy act (EEG) in Germany was installed in 2000 and recently modified. It provides utility rates for power generated by on-roof PV systems with 57,4 ct/kWh for plants with more than 30 $kW_p$, 54,6 ct/kWh for plants with more than 30 and less than 100 $kW_p$ and 54,0 ct/kWh for plants with more than 100 $kW_p$. PV components installed on facades receive an extra bonus of 5 ct/kWh. This payment can be collected for more than 20 years. The compensation rate for new plants is reduced by 5% every year to provoke further innovations in cost reduction.

[17] The tariff-system is only introduced for PV; the other renewable technologies have a quota/certification system.

tries have or plan to have comparable tariff-systems PV plays or will play a significant role in only a few countries.[18]

- ⇨ As general criteria concerning the *effectiveness and acceptability of an incentive programme* it was mentioned by several interviewed architects that the *long-term orientation* of a measure or an instrument is a crucial aspect for an investor. The example of guaranteed rates over a period of time was emphasised to *decrease the risk of investment* and attract private investors. In contrast, “stop-and-go” incentives (by discontinuous payments or loans of the state) are an important barrier for the development of a young market, specifically the participation of smaller (entrepreneurial) companies with lower capital bases.[19]

On the other hand the incentive scheme should enable and foster *innovation* at different levels:

- ⇨ To enable innovation concerning the *diversity of products, design* and developments for different applications the promotion scheme could be divers and variable itself and should reflect the different PV options and their costs. For example, the German feed-in system subsidizes the higher costs for PV façade systems (see above). Because of the big innovation and application potential of PV technology, it remains important to support several long-term R&D projects.

- ⇨ At the same time *innovations to lower costs* have to be fostered. Referring to the example of tariff-systems, a constant decrease of the payment (e.g. per kWh, like in the German EEG) could be a suitable mechanism. In this field a lot of R&D is needed in combination with creative and powerful companies who have an interest to produce for the market and to lower production costs.

Besides the national level and the implementation of general instruments to promote PV, a lot of support can be done – and was already done in several communities - at local level.

- ⇨ Several ways that local governments can support PV are to: implement frameworks to promote PV, build plants in public buildings, give financial support or inform the community. One result of the study was that the majority of the interviewees were in favour of a larger engagement of their local government concerning the promotion and use of PV.

An important and well-known example of a successful deployment strategy is the framework of Barcelona (Solar Thermal Ordinance of Barcelona) that instructs the use of solar thermal plants for new and restored buildings.[20] Barcelona is thinking of integrating PV into this regulation. The Barcelona framework has already been imitated by several Spanish cities (like

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[18] At present 17 countries of the EU-25 already have a tariff-based system for the promotion of renewable energies or are planning to implement such a system (Reiche 2005).

[19] Stop and go-examples with significant impacts on the PV markets are known in Germany during the time of the 100,000 roof-programme and also in Italy between the former financial incentives and the feed-in law coming into force in the late summer of 2005.

[20] For additional information see Puig (n.d.).

Seville and Madrid) and the Spanish Government is planning to implement this on a national level. Also in Germany, some communities (like Vellmar and Hamburg) have used such a regulation for new residential building projects.

In addition to this regulative approach, voluntary initiatives like providing consulting or information can foster the distribution of PV. One example is the solar power roof initiative in Berlin that offers private investors the opportunity to install PV plants on public buildings.[21] In return, the senate collects a small commission. Such programmes also guarantee financial incentives for communities supporting PV deployment. Another initiative is currently being introduced by the city of Rome; it gives out special permission to developers who apply ecological principles (including solar technology). They may use up to 5% more volume than conventional buildings.

To reduce the costs of PV, further innovation is needed like new and cheaper cell types, but also other approaches should be investigated and developed. The following suggestions were mentioned by interviewees and experts throughout the study:

- ⇨ Multifunctional PV modules, like the combination of power and heat generation
- ⇨ Building-integrated PV components such as solar roof tiles,
- ⇨ Multifunctional facade elements: additional functions apart from power generation could include heat insulation, light transmission or transparency, air conditioning, and design. As it is difficult to generalise a cost-benefit analysis for such multi-tasking applications, databases with best practice examples should be built and analysed.

## 3.4 Positive Multiplier Effects in Tourist Areas

The approach of the project was to implement PV technology in difficult surroundings like protected areas or buildings under monument protection, in order to show that good and adaptive design solutions are feasible with new innovative PV technology. In addition, imitation and multiplier effects could play an important role for the distribution of PV. Protected areas are often tourist hot spots and many people, sometimes from all over the world, could come in touch with PV. In our study this specific multiplier effect was rated high amongst both countries. The following recommendations stem from the results of the study and on other experiences made during and after the building of the PVACCEPT demonstration objects:

- ⇨ More positive and successful PV design examples have to be built. Therefore the administrative barriers have to be eliminated (see next recommendation) and knowledge of all involved key stakeholders improved (see above).
- ⇨ Information about the PV projects and solar technology in general should be presented in a logical way near the installations.
- ⇨ Solar design examples (buildings, art, production companies) could be integrated into advertising campaigns for tourists.

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[21] For additional information see Stadtentwicklung Berlin (n.d.).

⇨ Tourist activities like solar excursions, round trips etc. could be developed as holiday activities combined with information.

## 3.5 Administration and Authorisation Procedures

PV is currently facing strict regulations. Sometimes implementation is forbidden or requirements concerning look and integration are prohibitive, especially in protected areas (such as the choosen sites in Italy and several locations in Germany). The experiences and results of the study with regard to administrative staff and potential supporters, like mayors or politicians, were twofold. On the one hand, we experienced a lot of support that “brought down walls”, even regulatory walls hindering the implementation of PV. Because of this support, the four PV projects were successfully built. On the other hand, other involved or interviewed persons had very little knowledge and sometimes deep prejudices about the appearance of PV. Additionally, authorisation procedures are normally long and complicated in both countries. In response, we recommend the following:

⇨ Regulative framework and local education: First, the general directions and administrative instructions that prohibit PV in general should be eliminated. That does not mean to eliminate any monumental protection, because monumental protection is seen also as an important socio-cultural task. It should be possible for local level administrators to assess on an individual basis each architectural project that wants to implement PV technology. Therefore local competence is needed – first on the regulative and second on the educational level.

⇨ Success factors for the administrative process:

- The relevant authorities need to be involved into the project as early as possible.
- Simulations, pictures, and drafts to show and explain the planned project are very helpful to reduce prejudices and misconceptions.
- It is important to identify and involve key people from inside administration who are highly motivated and maybe have a personal interest in the success of the project. They can help and follow the process, influence decision-makers and stand up for the implementation of the project.
- Create different design and function options to show the adaptability and flexibility of the modules.

A combination of these factors was the key to success in Italy. A regional territory framework plan, the early involvement of protection authorities and the presence of interested and committed personalities within local administration accelerated the construction of test projects in Italy. The lack of these factors led to the failed attempts in the first research region in Rügen, Germany.

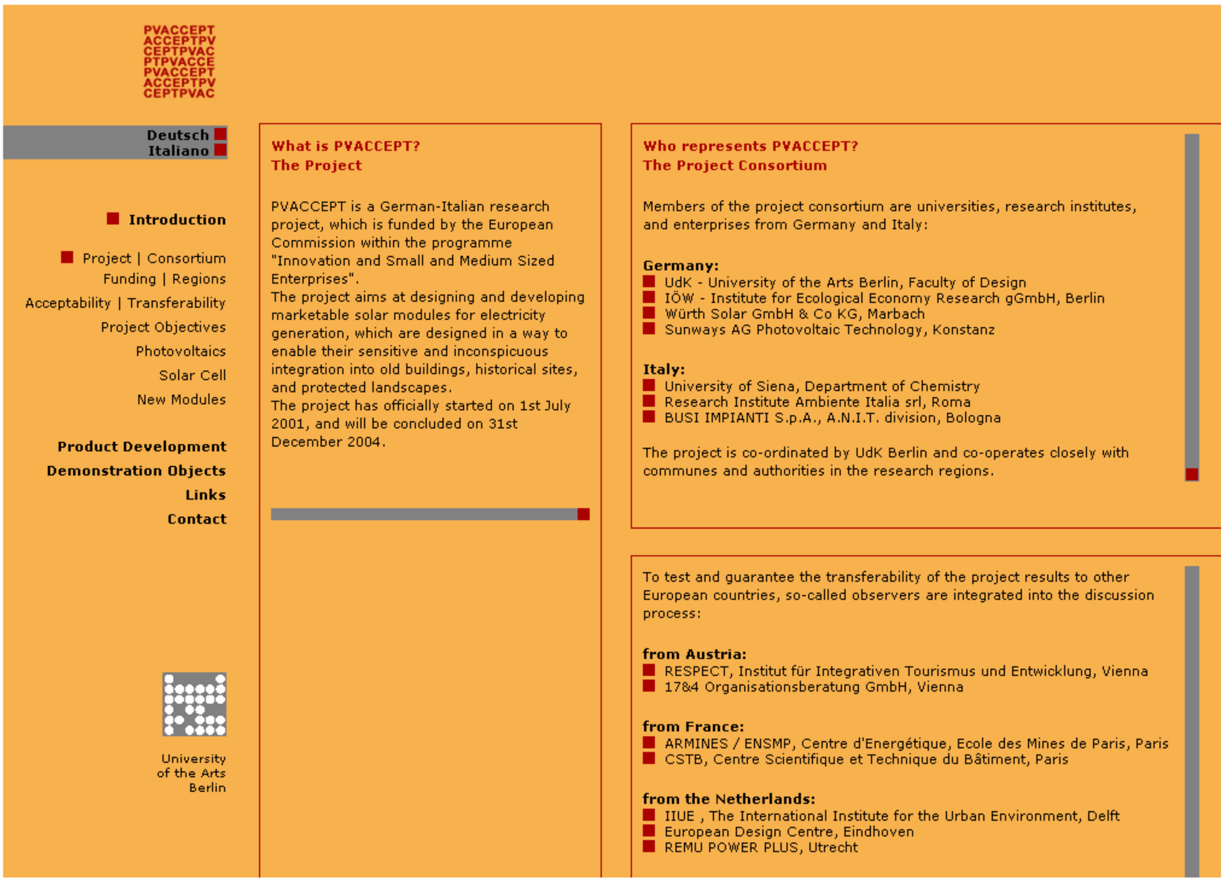
## 3.6 Effects on Acceptance initiated by PVACCEPT

A number of activities within the project caused positive side-effects, as they spread information about PV technologies and innovative designs. In this way, the project itself helped to strengthen acceptance of PV on a local and regional scale and within “connected” communities (e.g. involved scientists and administrations). Examples from these project activities are:

⇨ The installed and virtual design PV projects in both countries can be seen as models for further development. The built PV systems will last longer than the project duration time and their maintenance is ensured by the involved community and/or PVACCEPT partners. All built objects, but also the virtual models received very positive feedbacks from population and professionals.

⇨ The project PVACCEPT provided knowledge and influenced the acceptance of participants. The communication and information offered by PVACCEPT included: training, press conferences, public inaugurations of demonstration systems, talks and interviews with decision-makers and authorities, and workshops. Furthermore, a design manual and an travelling exhibition was developed by UdK Berlin as a dissemination tool.

⇨ PVACCEPT provides its own website (see screenshot) that will be accessible beyond the official end of the project.




*Picture 7: Website [www.pvaccept.de](http://www.pvaccept.de)*

## 3.7 Need for Further Research

To reiterate the main statements, this study indicates that knowledge and especially design of PV modules - so far underestimated aspects - play a crucial role for acceptance and therefore further distribution of PV. In some target groups, the role of design plays a higher role than economic factors (costs). The surveys also proved that successful implementation of technologies in “difficult surroundings” (protected buildings and areas) could be accomplished. Large majorities of architects and communities positively valued virtual or real images of PV objects in such surroundings. Moreover, the results support the thesis that positive multiplier effects (concerning information, positive attitudes etc.) could be achieved following the application of PV in highly frequented tourist areas.

However, the implementation of the PV projects was a complex, long and difficult process due to (amongst others) restrictive regulations. Often PV promotion and knowledge was missing within administrations and local authorities. The conclusion can be drawn that a change in regulations, authorisation procedures and education of administrators is necessary. In addition, better design options for PV and increasing numbers of customized models will lower problems of acceptance.

- ⇨ Developing prototypes of (re)designed PV modules, cell types and several design examples as done within PVACCEPT seemed to be a successful first step. Future projects should include and address: elimination of regulative barriers, development of more design options (module/cell variety) and creation of additional best practice examples.

Further and more specified recommendations for research are:

- ⇨ Detailed research concerning the role of aesthetics is needed. The results of this study could be broadened and tested by representative surveys, including a more differentiated analysis of design variability and potential and target groups.

- ⇨ With regard to common trends, the surveys also showed important national differences. Results are not simply transferable; instead it is crucial to carry out further research in other countries. Detailed knowledge of basic conditions is mandatory for the acceptability of PV applications. These conditions include socio-cultural and economic aspects (e.g. different incentive schemes in each country).

- ⇨ Further research should be carried out concerning economic factors of acceptance. Incentive schemes fostering both technical and creative innovation should be developed and assessed. In addition, feasibility studies of PV implementation in buildings demand better methods to evaluate microeconomic influences. This includes further assessment of benefits from additional functions like insulation, control of light and shade, air conditioning etc. or the substituted materials of the façade.

- ⇨ To build up new markets for innovatively designed modules (e.g. finding and linking target groups with intermediaries and appropriate financial schemes) marketing research is needed, especially to support involved SMEs.

# 4 Summary

Public awareness of climate change and rising costs of fossil resources moves renewable energy into the centre of attention. In terms of sustainable development, European countries support solar energy as one important energy source to increase environmentally-friendly power generation. The German-Italian research and demonstration **project PVACCEPT** tested new ways for improving and increasing the implementation of photovoltaic technology (PV) and broadening its acceptance. Many European surveys dealing with attitudes and values show the high general acceptability concerning renewable energies, especially solar technologies. But these positive attitudes do not lead automatically to a corresponding behaviour. In the centre of current discussions about renewable energies are costs and subsidies. PVACCEPT started with the **main thesis** that acceptance is another crucial factor for a broader implementation of renewable energy. Design in particular influences the acceptance of solar technology since the installations are visible architectural components.

The main subjects of the PVACCEPT research were the development of innovative PV modules and cells, their implementation in demonstration objects and the investigation of different acceptability aspects. The methodological approach of the acceptability study included workshops, interviews and surveys retrieving specific indicators of acceptance from local population, key actors and professionals within the field. Challenging locations served as test sites, where the final implementation of PV modules had to overcome strong restrictions and induce positive multiplier effects. The PV modules developed were designed in a way to enable their sensitive and inconspicuous integration into old buildings, historical sites, and protected landscapes. The solutions were designed to convince monument and landscape protection authorities that modern technology does not necessarily contradict preservation of cultural heritage. German and Italian scientific teams cooperated in concept and execution of the study so that national differences could well be recorded. These observations during the implementation of the PV demonstration objects are included within the final conclusions.

The results of the acceptability study substantially confirm the central assumptions of the project. In particular, the role and importance of soft factors like knowledge and design were scrutinised and confirmed. This does not neglect the important role of costs for a broader distribution of PV, as most of the respondents confirm them to be the main obstacle. Surprisingly, the soft factors knowledge and design were also assessed as important distribution factors for PV.

Several empirical results underline the important role of **knowledge about PV technologies** for acceptability. One important and basic finding was that the current level of knowledge concerning PV and solar technologies in general is still low. The majority (more than 60%) of the questioned population is not familiar with the fundamental difference between solar power and solar heating systems. Within the group of people who have basic knowledge about solar technologies and PV, the knowledge about subsidy and other supporting programmes is comparatively low. Reasons for this are the complexity of most supporting programmes and the often changing mechanisms or conditions. In most cases, Germans are slightly better informed than Italians, which seems to correlate with the degree of technology distribution. This general lack of knowledge should be addressed by broader initiatives, campaigns and educational programmes for different groups of society, especially for schools and teachers. Information tools require a certain simplicity regarding a target group specific language and knowledge.

Architects can play an important role in the distribution of PV as they are a source of information and design opportunities. But even in this important group of intermediaries the level of (specialised) knowledge is comparatively low. One central indicator for this is that most of the questioned architects are self-educated and the majority (many German and nearly all Italian architects) called for better and further education programmes dealing with PV technologies. This demand for education in solar technology currently does not meet the supply.

PV related knowledge was also at a very low among public administrators of local and regional authorities dealing with monumental or environmental protection. These authorities play a major role within the planning process of PV applications in protected areas. Therefore their level of knowledge can greatly influence the general “go or no-go” decision of implementation. In some cities, monument preservation affects not only single buildings, but covers complete city centers (especially in Italy, but also in Germany). Our findings show that the staff within these public authorities has a very low level of knowledge about solar and PV systems, and often this leads to prejudices about the general aesthetical look. Furthermore instructions “from levels above” sometimes prohibit the implementation of PV.

It must also be mentioned that SMEs (small and medium sized enterprises), especially in the construction and energy sector, are often very interested in using, investing or dealing with renewable energy. Such SMEs are also able to create positive multiplier effects; they can induce significant demand or want to enter this new market themselves. The important conclusion from SMEs in PVACCEPT training and workshops is that information and education are needed that reflect the specific needs and circumstances of SMEs.

The second central result of the study is that the **role of design** as an acceptability factor of PV modules has been underestimated. An aesthetic look of PV modules adapted to the specific requirements of the installation site can influence and improve the social acceptance of PV technologies and therefore the distribution of PV. In few words: **Design matters!** All together four sites were chosen within the PVACCEPT project to demonstrate innovative designs of PV; three in Italy and one in Germany. In addition, a considerable number of design drafts were produced as a basis for discussions with local stakeholders and as examples.

The built objects as well as some of the visualisations of possible other designs or objects were presented to and evaluated by different target groups. Both German and Italian respondents considered innovatively designed modules as crucial for building-integrated solutions. Especially the Italian answers showed great interest and sympathy for new PV designs. Overall, it was recommended to develop variable as well as adaptable cells and modules to achieve successful implementation in various environments. The response on the four built designed PV demonstration objects was overall very positive. While 40% of all persons interviewed in Italy and 25% at the German site considered standard PV installations as badly integrated and not good looking, the vast majority of respondents in both countries (up to 98% in Marbach/Germany) appreciated the PV installations of the PVACCEPT demonstration objects. A majority of interviewees expressed that they can imagine PV installations also in general on monuments, if the design is well adapted. These positive results call for more good design examples and for promotion and marketing to create multiplier effects.

The mentioned **multiplier or imitation effects** are seen in both countries as important distribution mechanisms to broaden the use of PV. Furthermore, the results of the study support the thesis that **tourist areas** are well suited to demonstrate the use of well designed PV technology as they offer advanced attraction and marketing opportunities.

To implement more successful PV examples like the built PVACCEPT demonstration objects, the **framework conditions** in many regions should be rearranged and “rules” for a successful co-operation should be followed. The general restrictions against the use of PV should be replaced by the allowance of individual assessments and decisions. This has to be combined with the needed education programmes for the respective authorities. A successful PV project should involve the key people from administrations early and continuously, providing visualised drafts with different variations when possible.

Developing prototypes of innovatively designed modules and several PV demonstration projects within PVACCEPT was a successful first step. However, this success should be the beginning rather than the end of research and demonstration activities. Future projects should include and address elimination of regulative barriers, development of more design options (module and cell variety), new markets and best practice examples.

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