Intelligent Energy Europe

PV UPSCALE

PV in Urban Policies- Strategic and Comprehensive Approach for Long-term Expansion

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Planning for Urban Scale Photovoltaic Systems

WP3 – Deliverable 3.6

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Executive Summary

This report describes the results of Work Package 3 (WP3) of the PV UP-SCALE project which focuses on urban planning and photovoltaics. The work was based on the review or development of plans to include PV in the construction of major urban developments. The results have been written up by members of the consortium as a set of detailed case studies and led to a summary of lessons learnt, recommendations and conclusions.

During the project participants engaged with groups of stakeholders considering actual or potential PV projects in their area. This led to the preparation and publication of case studies which provide a detailed look at the processes involved in making an urban scale PV project successful. The case studies were then used to determine common success factors, problems and solutions as described in this report. The group of case studies prepared has shown patterns and groups of problems, barriers and solutions that could not be shown from single case studies. Having different projects at different stages in the development process has provided a valuable overview of issues over the entire life of a project.

Actively engaging with stakeholders was a core element of this work on urban planning. The aim was to work with the stakeholders to develop plans for implementing PV in their own area or to review past projects. Engaging the stakeholders in this work led to significant increases in their knowledge and understanding of PV and the issues involved in implementing large scale projects in urban areas. In many cases it also led to greater enthusiasm for renewable technologies and PV and a genuine interest in including PV in current and future construction projects. A number of the new urban plans developed are continuing down the path towards implantation.

The case studies are in 2 groups, new urban plans and reviews of existing projects. The reviews of existing projects reviewed areas which had already installed significant amounts of PV. PV Up-scale reviewed the process by which they had got to this stage and the issues encountered on the way. Some of these areas had over 10 years of experience with PV to review and lessons learnt covered all stages from the initial idea of the project to maintenance and system performance.

The second group concerned urban areas new to PV and involved preparing plans for the inclusion of PV in future developments at sites in France, the UK and Germany. The initial concept was that these plans could be virtual plans with little probability of realization. However PV Up-scale succeeded in locating areas where new developments were being planned and the option of including renewable energy was of serious interest. For this group the PV Up-scale case studies are only able to give a snap-shot of the progress made in the 2 years PV Up-scale has been running. This is a very short time scale compared to the time that may be taken to develop and occupy a new urban area. The case studies therefore focus on the planning and design stage, rather than implementation and occupation.

In addition the following case studies have been prepared by participants in IEA Task 10:

1. Jvosai Town PV Demonstration Area (Japan)
2. Bairro do Padre Cruz, Lisbon, (Portugal)
3. Malmö (Sweden)

The US, Australia and Denmark have also promised to join this initiative and are preparing case studies to be added to the web site.

The results of WP3 are all available on the PV UP-SCALE website. This report brings together all the web pages relating to urban planning. They are really meant to be read on the web, with each section consisting of separate web pages with active links to the case studies and other documents available on the PV UP-SCALE web-site.

The PV-Upscale project

PV-UP-SCALE (*PV in Urban Policies – Strategic and Comprehensive Approach for Long-term Expansion*) is a European funded project under the Intelligent Energy for Europe programme (contract number EIE/05/171/SI2.420208) related to the large-scale implementation of Photovoltaics (PV) in European cities. Its' objective is to bring to the attention of the stakeholders in the urban planning process the economic drivers, bottlenecks like grid issues and the do's and don'ts within the PV process. To reach the urban decision makers workshops have been organised and a quality handbook has been written using experience gained with PV Urban projects in the Netherlands, Germany, France, Spain and the United Kingdom. The project complements the activities that are being executed in the International Energy Agency – Photovoltaic Power Systems Programme (IEA PVPS) Implementing Agreement, in particular IEA PVPS Task 10. It takes information from Task 7 (building integrated PV), which ended in 2001 and Task 5 (grid issues), ended in 2003.

The results of the project are fully described on the web site: www.pvupscale.org

The PV UP-SCALE consortium brings together complementary expertise from Educational, Research and Development, Engineering, Architecture and Utility sectors:

Sectors	
Educational,	**ECN Research Centre of the Netherlands ,** Research Institute, The Netherlands (Project Coordinator)
Research	**Vienna University of Technology - EEG**, Energy Economics Group, Austria
	Fraunhofer Institute für Solare Energiesysteme, Research Institute, Germany
	Universidad Politecnica de Madrid – Instituto de Energía Solar, Spain
Consultancy	**HORISUN**- Consulting, The Netherlands
	HESPUL- Consulting, France
	Halcrow Group Ltd, Consulting, United Kingdom
	Ecofys- Ecofys Energieberatung und Handelsgesellschaft GmbH, Consulting, Germany
Electricity	**Continuon-** Netbeheer NV, Utility, The Netherlands
	MVV- MVV Energie AG, Utility, Germany

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1. Urban planning - Introduction

Within **PV UP-SCALE** a wide ranging review has been carried out of urban areas where the installation of significant amounts of PV has been completed or planned. The aim was to identify common success factors and potential problems.

PV UP-SCALE participants worked with over 100 different stakeholders from policy makers, to engineers, architects and occupants in 6 countries to gather their experiences and opinions regarding the implementation of large scale PV within the development of urban areas.

The urban areas involved ranged from those where the priorities and plans for the area are still being shaped to areas where PV was installed over 10 years ago and issues of maintenance and the impact of occupants' behaviour can be assessed. In all of the areas the quantity of PV was significant, impacting substantially on the area where they are located. The range of countries, development stages and stakeholders involved has been extremely wide and this has led to the collection of a comprehensive set of lessons learnt and successful methods of promoting the implementation of PV within the urban planning process.

In this website key lessons and issues at various stages in the development of an area including significant amounts of PV are provided, backed-up with more detailed case studies. An initial set of PV UP-SCALE case studies are provided. These are complemented and expanded by further (Task 10) case studies gathered within Task 10 of the IEA programme on PV.

Arial view of Nieuwland 1 MWp PV project in the Netherlands

The lessons learnt are divided up into the 3 main stages of developing an urban area:

- Setting the stage – the impact of planning policy on renewables within urban areas
- Implementation – from design to construction
- Occupation – when the real success or otherwise of a project can be seen.

It is hoped that the information available will be useful to a wide range of stakeholders. To this end guidance is provided as to how to find the most relevant case studies for various situations.

The case studies examined are located in different countries. The urban planning process varies dramatically across the countries considered. In some countries such as the Netherlands the process is a top down one and is government led with issues from the architectural style to the environmental achievements defined before commercial developers are invited to bid. In other countries development is more bottom up with commercial organizations having a larger role in initiating, designing and planning initiatives under government limits and guidance. In order to provide some background and context to the case studies summaries of the national planning process are provided as it relates to PV.

2. Setting the Stage

The process of implementing renewables, including photovoltaics, in urban areas starts with national and regional policy formation and strategies; these set the context in which urban planners create plans for specific urban areas and developments. Plans are then implemented by developers working with builders and architects to construct buildings that meet the needs of the eventual occupiers and residents.

This section focuses on actions taken at the urban planning stage that can successfully set the scene for the implementation of renewables.

In the majority of cities identified as having installed significant amounts of renewable energy over the last 10 years the local municipal government has played a key role in stimulating projects. Key factors identified as being common to cities where large amounts of PV have been installed include:

- A strong local political commitment to the environment and sustainability
- The presence of municipal departments or offices dedicated to the environment, sustainability or renewable energy
- Obligations that some or all buildings include renewable energy
- Information provision about the possibilities of renewables
- Challenging development sites which seem to have inspired some very ambitious renewable energy projects.

In cities where a political commitment to renewables and sustainability has led to successful projects positive results and feedback from the projects has strengthened and reinforced the political commitment and led to further projects. A positive cycle can be set up, with good projects leading to further projects and the continuation of supportive policies. Methods of providing feedback to political bodies that can have a positive impact include:

- winning environmental awards (this can result in positive publicity for the city and in some case monetary prizes that can be used for further projects in renewables)
- ensuring positive impacts on the local economy or consumer's energy behaviour are identified and fed back to the decision makers.

Proactive municipal environment/sustainability departments or officers can make an enormous difference. They can play a key role in defining new development areas with a renewable component, linking up developers and architects of suitable building projects with information on renewables and provide assistance in obtaining funding. They are also involved with the drafting of supportive local policies and ensure the wider results of renewable energy projects, such as the impact on the local economy are fed back to political bodies and lead to the continuation of supportive policies.

Obligations to include renewable energy in new developments can take different forms. In the UK a planning rule that 10% of the predicted energy demand from new developments must be supplied by renewables (also known as the Merton rule after the London suburb where it was first applied) is rapidly being taken up by municipal authorities and is a major driver towards the implementation of renewables in the UK.

In the Netherlands entire new cites can be defined in a top down approach and can include requirements for renewables. This has led to some massive projects such as the Stad van der Zon (City of the Sun) in the HAL region (Heerhugowaard, Alkmaar and Langedijk), see case study.

In France and Germany municipalities can define new quarters but the development of individual buildings is up to private investors. The role of the municipality is to set targets and to inform and inspire investors. Some municipalities have found methods of setting specific requirements for the implementation of PV. For example in Gelsenkirchen in Germany the city is imposing solar requirements in the contract of land purchase, see case study.

Decisions to include renewables in a development can also originate from land owners, developers and architects. For example a new solar housing estate is planned close to the Centre of Cologne. Here the landowner plans to create a solar housing estate with around 120 dwellings. In order to gather ideas an architectural competition was set up where 8 well-known architects were invited to realise an urban plan consistent with solar requirements and building types fitting in the concept of solar housing. The project received funding from the energy agency of North-Rhine-Westphalia under a program to stimulate the development of solar estates.

Many of the projects reviewed obtained funding through public funding programmes; however capital funding programmes supporting PV are become rarer. Some projects such as the Schlierberg solar estate in Freiburg and the communal PV power plant in Gleisdorf used innovative financing mechanisms such as shares. There is a Europe wide trend away from capital funding, but enhanced payments for renewable electricity are becoming more widely available. Capital funding tends not be available when obligations are imposed on developers to include a certain proportion of renewable power generation in new developments instead the provision of information is the crucial factor.

Information can be provided by different actors at different stages. Croyden in London was one of the first municipalities to impose a planning rule of 10% renewables contribution for new major developments. They see the main barrier as know-how, not cost, so the Croyden Energy Network's Green Energy Centre provides advice and support to developers on accessing grants and types of renewable technology to use.

In Lyon the local energy agency organised technical visits to renewable energy systems for housing associations. This initiative led to the La Darnaise project with PV on the facades of refurbished apartment buildings. A major redevelopment of the confluence area near the centre of Lyon is now underway and information is being provided by an informal group of local experts.

The final common factor noted in many of the innovative PV developments was that they were often based on challenging development sites. These more challenging sites seem to have inspired creative approaches and led to the inclusion of renewables in some major developments. Examples include projects to redevelop old industrial areas in Lyon, Barrow, and Gelsenkirchen. The inclusion of renewables formed part of a strategy to transform the image of La Darnaise near Lyon which had a problem due to past riots in the area.

Case studies of all the PV developments mentioned are available on the web-site. Some municipalities such as Amersfoort in the Netherlands, Freiburg in Germany, Kirklees in the UK and Gleisdorf in Austria started supporting renewables many years ago and now have a range of renewable installations in their area plus stronger local economies and national reputations as centres of excellence for renewables.

Other municipalities are midway through a process of promoting renewables and have initiated major developments with PV. These include Gelsenkirchen in Germany, Croyden in the UK, Lyon in France and the Stad van der Zon in the HAL region of the Netherlands. Finally municipalities such as Cologne and Berlin in Germany and Barrow in the UK are just now starting the process of promoting the installation of renewables.

3. Implementation

Historically most of the PV systems installed have been one offs rather then groups of systems in new urban developments. However sustainability is becoming a more important issue for the construction industry and photovoltaics are a key technology with the potential to generate electricity in urban areas. If photovoltaics are to make a significant contribution to reducing CO_2 emissions from buildings they will need to be installed on a larger scale than at present.

Compared to one-off buildings installing large groups of systems can present new challenges. Many of the problems are due to the fact that there is a very limited amount of experience with PV in the wider urban planning, development, construction and electricity generation sectors. Administrative and regulatory systems are not yet well adapted for groups of small distributed generators. The technology itself causes very few problems and involved professionals have commented that it is surprisingly simple to deal with once the fundamentals are understood.

Photovoltaic systems are unlike many other technologies included in buildings in that they are best taken into consideration right from the beginning. Advice from a specialist with solar experience can enhance the feasibility of installing PV and optimize the cost and performance of the PV. As experience is gained across the industry, and understanding of PV and its implications for site layout and planning become a standard part of planners' and developers' repertoires the process will become easier.

PV UP-SCALE has looked at number of the projects where photovoltaics have been installed at a larger urban scale, either as part of new developments or retro-fitted to multiple buildings within an urban area. In this section we look at the lessons learnt and problems encountered implementing these projects.

The first challenge is to get solar access considered in the initial planning of the urban layout. After this comes the challenge of including PV in detailed design and construction.

See the following sections on:

- Urban planning and solar access
- Requirements for Successful Implementation

Note this website does not provide design advice for individual PV systems. Good design advice for systems is already available from many other publications; see the links section of the web-site for details.

4. Urban planning and solar access

Many aspects of the urban planning and development process, from the layout of the roads to the building massing and shape of the roofs, will crucially affect the feasibility and performance of any PV systems installed. However in a new development planners may define the site layout before solar access is raised as an issue, and infrastructure such as roads and electricity supply may even be installed before developers are appointed.

If solar access is taken into account at the earliest planning stages, in the same way as car and pedestrian routes or the need for parking, it is usually possible to ensure that the majority of buildings on a site are orientated between South East and South West to have good solar access. If it is not taken into account there is a risk that many of the buildings will have poor solar access. Not only will this lower the feasibility of installing photovoltaic systems, it will also restrict the use of passive solar design techniques, daylighting and solar water heating. The resulting urban layout will be in place for hundreds of years, restricting the feasibility of using any of the solar technologies now and in the foreseeable future. The presentation by Kees Duijvestein on PV in the urban planning process at the European seminar on PV and Urban Planning, March 2008 gives more details on PV as part of sustainable urban planning.

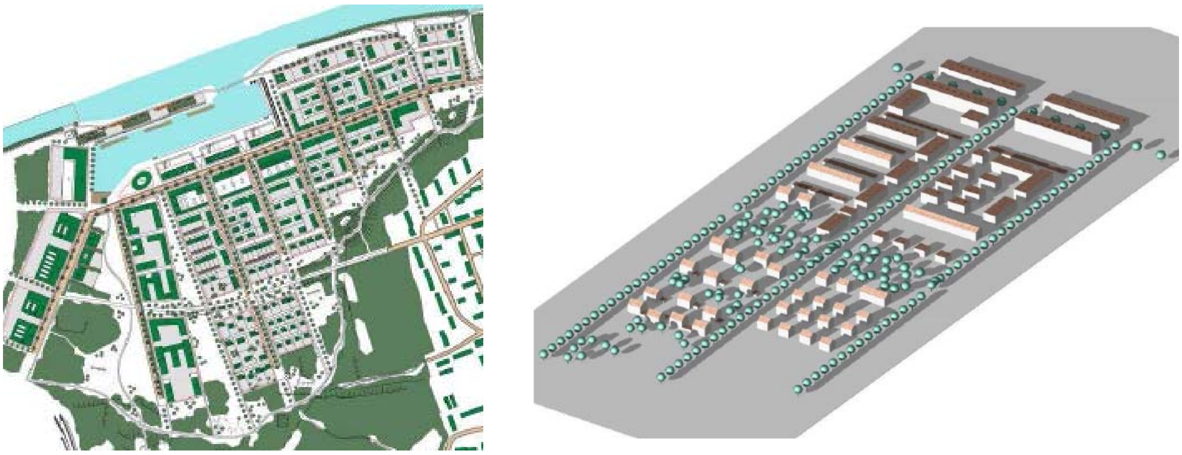
The sizing and layout of the electricity supply network may also be fixed fairly early on. However with moves towards sustainable construction there is an increasing trend towards micro-generation of electricity in buildings. These micro-generators can range from micro-CHP systems to micro-wind to PV. The Distribution Network Operator (DNO) may need to take such embedded generation into account when designing the local electricity network. See the section on grid connection for further details.

At many of the developments where PV has been installed the decision to include PV was made at a late stage, long after the site layout had been fixed. In many cases developers or builders who had become interested in PV had looked at the projects that were already underway and selected areas where PV could be installed on the basis that the development site concerned happened to have a good solar layout. Other sites available were not suitable for PV due to factors that could easily have been changed if they had been considered at an earlier stage. If we do not start taking solar access into account earlier in site planning the proportion of buildings that can make use of solar energy will be a fraction of what it could have been.

The approach towards urban planning, who undertakes it, when and at what level of detail varied quite dramatically between different countries, even the term ‘town planning’ means different things in different places. In some countries it appears to be easier than in other countries to include PV early on in the urban planning process.

In the Netherlands top down planning of major new developments is normal. As part of this there is a long consultative process during which PV may be added and urban designs modified. The Nieuwland case study reviews the first large urban PV project, realized in 1999, here solar optimization was taken into account in the urban planning phase with the land being parcelled out to provide as many roof surfaces as possible suitable for the installation of solar panels. The Stad van der Zon (City of the Sun) case study, again in the Netherlands also took the sun as one of the starting points in the urban planning, although there have been some comments that this was more as a philosophical approach than a practical, technical approach.

The approach is slightly different in Germany where the case studies demonstrate a willingness on the part of some municipalities to commission detailed analysis and shading simulations of urban renewal or development areas and use the results to inform developers and building designers. At Gelsenkirchen-Bismark, for example, an overall urban plan was developed which included a simulation of shading and solar irradiation on building surfaces. The initial draft of the area plan, with building massing and layout was evaluated and some modifications suggested regarding the height and distance between the buildings in order to provide each building with an ideal sun exposure. To avoid major shading of the building surfaces an advisory committee was formed to assist individual investors.



Shading visualization and urban plan Gelsenkirchen-Bismark

Also in Germany, a solar urban master plan was prepared for Berlin in order to determine the solar potentials of the different city quarters. The results were brought together with an urban renewal programme aimed at stimulating investment.

In both France and the UK the case studies available mainly reflect PV being added into an urban plan at a later stage in the urban planning process. This may relate to responsibility for detailed urban planning being more split between municipal planning departments, who tend to set guidelines rather than prepare detailed plans, and commercial developers who are then responsible for a greater part of the detailed urban planning. These breaks in the chain can make it much harder to carry a plan through to completion.

4. Requirements for Successful Implementation

Once a decision has been made to implement solar technologies in a building development and a "solar friendly" layout adopted or a building development with a suitable layout identified work can begin on implementation. A number of elements will be then be required to realise the solar installations:

- A champion of renewables/PV to take a lead on including sustainability, renewables and PV into the plans.
- Technical knowledge: This will be needed by the project leaders and overall planners, the PV engineers responsible for the design of the PV system and the rest of the project team. The project team will not need a detailed understanding but they will need some understanding of the implications of the solar system for their area of responsibility.
- Inclusion in the work plan for the entire project team: Installation of a PV system will affect other members of the team, not just the PV installer, and they need to allow for it.
- Time: The implementation of renewable energy projects has to fit within the construction timetable or there will be delays and extra costs. If the PV is added to the design late in the day it can result in compromises having to be made.
- Transmission links: A connection to the local electricity network will be needed. This should be included in the planning from the earliest possible stage.
- Money: Can it come out of the existing budget? If not, can money be raised from external funding sources or innovative financing?
- Enthusiasm: Last but not least there has to be some enthusiasm for renewable energy or the project will not result in the hoped-for emissions reductions.

Good communication between the different members of the project team is also important. Architects and engineers can appear to talk different languages at the best of times. The problem can be even worse when dealing with a technology which is new to some members of the project team. Clear communication between the team members on what they hope the PV can offer and the information they need should be discussed at an early stage in the project.

A renewables/PV champion

At the earliest stages someone needs to take a lead on including sustainability, renewables and PV into the plans. In some cases they are themselves sufficiently expert in PV to provide the technical knowledge needed at this stage. In other cases they have commissioned experienced PV consultants and designers to provide advice.

The renewables lead can come from many different places. In some projects the early lead has come from the municipality. For example in Kirklees in the UK, the municipal environment unit brought together developers and PV specialists to enable the creation of PV projects. The municipality had the knowledge, confidence in the technology and contacts to provide the initial set of information required. This was crucial in getting the developers started with their first PV projects.

The lead can also come from the building owner such as in the Cologne-Wahn case study where the landowner organized an architectural competition at the beginning to gather options for achieving a solar estate.

In other cases the lead has come from the architect, for example the Solarsiedlung am Schlierberg project in Freiburg, Germany was led by architect Rolf Disch, who wanted to provide evidence that his idea of an Energy-Surplus-House® can work well for terraced houses and commercial buildings.

The role of championing the renewable/PV aspects of a new development is a crucial one. If there is no champion these aspects may be shunted aside by others who see them as a risky unknown. Note that the champion has to be directly involved in the development, be aware of progress in all areas and be sufficiently influential that he/she can keep the PV system on the agenda. If the champion is not in the whole loop they may not be aware of issues that will affect the PV, such as design modifications, until it is too late.

The design engineers responsible for the detailed design of the solar system are likely to be experienced in the technology. However they may not be in a position to champion the PV project or to provide expert advice to the rest of the design team. The design engineers may not be appointed until quite late in the development process, especially if they are sub-contractors to the main mechanical and electrical sub-contractors. They may also have very limited influence or even contact with other members of the development team.

Technical knowledge

The design engineers responsible for the detailed design of the solar system are likely to be experienced in the technology. They can be expected to understand the available systems and how to design and install them.

However the rest of the project team will also need some understanding of the implications of the solar system for their area of responsibility. The solar system will impact on building layout and positioning and hence road and path layouts, roof shapes and structures and positioning of chimneys and vent pipes as well as the electrical distribution system. Someone will need to be responsible for making arrangements for the export of electricity and whoever is responsible for sales of buildings will need to be able to explain the system to potential occupants.

Unfortunately most engineering offices and developers today have very little experience with PV technology. Lack of knowledge by the rest of the project team can lead to a perception of risk, fear of delays and extra costs being imposed to allow for the uncertainty. Having an explicit plan for providing training, advice and visits to completed installations in order to transfer knowledge to the rest of the project team is the best way of ensuring issues are foreseen before they become problems. Many different approaches can be used to transfer knowledge and experience, but the approach used has to fit in with the development process in the country concerned.

The Lyon-Confluence case study gives an example of the successful transfer of knowledge. The guidelines for the selection of developers required the team to include an engineering office specialising in energy efficiency and renewable energy systems. However it still appeared that none of them had any serious experience in PV. To remedy this lack a team of local specialists was set up to assist engineering offices and developers at all stages of the project, from the preliminary design to the commissioning of PV systems. This local team also organised site visits and training sessions and is helping developers in dealing with a complex financial scheme with multiple sources of funding

The confluence project learnt from previous smaller projects in the Lyon area, such as the Les Hauts de Feuilly housing development where PV was brought in fairly late after developers had been appointed and the site layout fixed. PV was able to be installed on a group of houses at Les Hauts de Feuilly, most of which had a good orientation. However the orientation varies and is not optimal for all houses. Grid connection was also considered late and additional connection points had to be retrofitted at the utilities' cost.

Detached houses at Les Hauts de Feuilly showing PV systems with different orientations

Another example of technical information being passed on effectively is the Stad van der Zon, in the Netherlands. Here a new town area is being developed with PV on houses constructed by different architects, developers and builders. As soon as the detailed urban design and architectural aspects were in sight, a PV workshop was organized for architects and PV system manufacturers, resulting in draft designs and a book. The workshop was repeated in 2002. From a technical point of view, there were no problems in the design and realization of this ambitious project. There have, however, been major problems with the funding, as well as incompatibilities between the development timetable and the timescales required under the final funding arrangements.

Inclusion in the work plan

The urban development process tends to be complex, with a lot of issues needing to be taken into account. Everyone involved in the development is likely to be very busy and to have a defined scope of work which may not mention PV. Within the overall development of an area, PV has a very small role and cannot be expected to be high on the priority list of everyone concerned. However each of the following points needs to be explicitly included in someone's work plan. This should be backed up by access to expert advice whenever queries arise.

- Site layout for solar access.
- Building design with suitable surfaces for PV systems considering solar orientation and shading. Also minimizing cable routes and providing an accessible location for the inverters.
- Negotiating any planning amendments for the PV system.
- Roof structure and any extra weight or wind load from PV.
- Design and installation of PV system, likely to be a specialist sub-contractor.
- Lightning protection.
- Scaffolding, secure storage and insurance against theft before installation.
- Electric network layout for the site including co-ordination with the DNO. May need to be done before installer appointed.
- Electrical design in the building; needs co-ordination between PV installer and electrical contractor.
- Electricity export may need negotiating and tariff agreeing; this should not be left to individual building owners to deal with once buildings are sold.
- Solar training and awareness.
- Consideration of arrangements for servicing and maintenance once buildings are handed over.
- Funding.

Time

Considering the possibility of solar technology being included in the development site as early as possible will maximize opportunities for designing in good solar access and exploring synergies between PV and other aspects such as shade provision, day lighting and environmental image.

Difficulties in fitting a PV project into a development timetable can cause many problems. If PV is added late in the timetable it will often lead to less-than-optimal designs. If external funding is required, another level of complexity is added with difficulties matching dates of funding rounds, and restrictions on the dates that money must be claimed by. It may even be necessary to have two versions of the design, with implementation of the PV version being dependent on award of funding. Major developments have many constraints and hurdles to overcome, and PV is only a minor part of the overall picture. Waiting for PV funding cannot drive the timetable, a fact some funding organizations appear to be unaware of.

Grid connection

Photovoltaic systems in buildings are part of the building electricity distribution system and hence are normally connected to the local distribution grid. Technically, connection to the grid is straightforward so long as the local grid can absorb the extra power without exceeding voltage limits. However, agreement to connect to the grid must be obtained from the local Distribution Network Operator (DNO). In addition, a contract for the sale of electricity, at an agreed tariff, is normally required unless extra electricity is spilt to the grid with no payment obtained. Significant delays and additional costs can arise if discussions with the DNO are left too late.

Large PV systems, or large groups of systems, should be taken into account during the design phase of the distribution grid in order to correctly size the new distribution grid and avoid any additional infrastructure work once buildings are completed. Attention should be paid to the location of medium voltage/low voltage (MV/LV) transformers and the size of transformer feeders to make sure that each PV system can be connected to a suitably robust LV grid. Single systems or small groups of systems can normally be connected to the existing grid without any modifications.

Dedicated connection points may be required for contractual reasons. For instance in France, in order to benefit from the feed-in tariff for all of the energy produced by a PV system, the utility has to create an additional, dedicated connection point. So for a new development of houses with PV the DNO may need two connection points for each house, rather than the normal one. Unfortunately, the current administrative system officially requires detailed information about power plants before the DNO can take them into account. As the detailed information required is unlikely to be available during the infrastructure design phase, there is a potential problem.

At Les Hauts de Feuilly, France, a group of 19 houses with PV roofs needed dedicated connections to the grid. However, the DNO was not officially informed of this until the houses were complete. The problem delayed the commissioning of all PV systems while dedicated connection points were installed. In this case the extra costs involved were borne by the DNO, rather than the inhabitants, as the power of each PV system was below a certain level.

At the subsequent Confluence project in Lyon the designers were aware of this potential problem so organized a technical meeting with the DNO to find a way, during the design phase of the distribution grid, to take into account the fact that several buildings would be equipped with PV. The objective was to correctly size the new distribution grid to be built and avoid any additional infrastructure work once buildings are completed.

Having individual building owners regarded as generators, with all the associated regulatory requirements, is a very recent phenomenon. Appropriate administrative procedures are not yet in existence for dealing with groups of small identical generators. Standard procedures for export of electricity normally require complicated and time-consuming forms to be filled in. However, if the forms are to be completed by individual householders and this is left until the houses are occupied, problems and delays are likely to result.

Experience at Les Hauts de Feuilly housing development in France led to suggestions that a developer that chooses to install PV systems on its buildings should assist future home owners until the commissioning of the PV system. In particular, developers should make sure that future home owners have signed the contract for the connection of the PV system to the grid with the DNO and the contract for the purchase of the electricity produced at a specific feed-in tariff.

Financing
PV is undoubtedly expensive. Most urban-scale PV projects to date have obtained some level of capital funding subsidy, but subsidies are becoming harder to obtain. In some countries their role has been replaced by funding paid via premium rate feed-in tariffs for renewable energy. This guaranteed income can allow finance to be obtained through loans.

Sources of funding range from the European Commission (which tends to fund larger projects but not individual buildings), national or regional renewables programmes, which tend to be more accessible to smaller projects, and local municipal or utility funding. Those municipalities which have created renewables funds, such as Kirklees – which decided to set up the Kirklees Council Renewable Energy Capital Fund in 2000 – have been able to get a range of projects going in their area and start up local supply and installation companies.

If no subsidies are available the full costs may be met by developers or builders, and then passed on to the purchasers of the building. If there is an obligation that all new buildings in an area install renewables, then anyone who wishes to own a building in that area has no option but to pay the cost. If there is no obligation then such buildings have to be marketed at a premium price justified by their sustainable design. The viability of that depends on the local market and preferences of purchasers.

In some locations, such as Croyden, London (UK), there is evidence of higher property values for properties with PV systems. Here, some developers obliged to install renewables have found PV the most cost-effective solution because it does not take up any space in the house, and the cost of the space needed for a hot water tank for solar water heating outweighs the higher outlay for PV.

Some projects have raised money by selling shares. The financial feasibility of this is improved in countries where a premium feed-in tariff is paid for electricity from PV.

In Gleisdorf Austria, a 10.44 kWp communal PV power plant on the roof of the offices of utility company Feistritzwerke-Steweag was the first PV power plant in Austria realised through a shareholder programme. This project made it possible for environmentally engaged people to own a share of a PV power plant. Initially, sales of share certificates were slow. The project manager put a lot of effort into advertising the project and in the end, 68 people bought shares which financed 80% of the costs; the remaining 20% was financed by the utility.

In Freiburg, Germany, financial difficulties were encountered during the development of the Solarsiedlung am Schlierberg eco-housing estate. These were solved by starting a fund, called '1. Solar Fond Freiburg,' with an invitation for subscription to share certificates of €5000 each. The shareholders were primarily private citizens who wished to make a sustainable long-term investment. The total investment was €1.5 million. This new financing model was the key to success. The first one was followed by three other investment funds with a total investment of €3 million each. In total, 15 rental houses belong to these four solar funds. The roof integrated PV systems were marketed separately. Either the homeowners or other investors purchased them. A return on investment is granted by the 20-year payment of the feed-in-tariff under Germany's National Renewable Energy Act.

Enthusiasm

Once upon a time renewable energy projects were few and far between. The ones that were implemented tended to come about as a result of enthusiastic and knowledgeable individual clients, architects or engineers. The knowledge and the enthusiasm were there, at least in part of the design team. The problem was to raise the money, fit it into the timetable (often complicated by having to wait for results from funding bodies) and get the rest of the team on board.

Today the inclusion of renewable energy in a development may be a requirement imposed by others. There may be little knowledge and less enthusiasm in the design team. However on the plus side if the requirement is there from the beginning the timetabling may be easier and implementation of the renewable energy aspects is less likely to be dependent on winning some form of competitive fund raising procedure. The challenge today is moving from locating funding to providing knowledge and enthusiasm.

Fortunately experience shows that enthusiasm tends to arrive naturally with knowledge. Once a commitment has been made to include PV in a development, results from many projects suggest that developers and architects are often surprised at how easy a technology PV is to design with and install. The key is spotting issues at the right time and providing access to the information needed.

As more and more PV projects are implemented, so PV will become part of the standard repertoire of architects and engineers. The need for training and information provision by PV specialists will reduce. There may also be a reduced level of uncertainty on the part of clients and other members of the project team, which should lead to further cost reductions.

6. Successful long term operation

PV systems are expected to have a long life time successfully producing electricity at, or close to, their original output level for at least 20 years. It will take a few years for the PV system to generate the amount of energy used in its construction. Only after this point is reached is the system having a positive impact on climate change or oil depletion.

While the majority of PV systems operate well for many years, this is not always the case. A design that does not make it sufficiently easy for the occupants to check system performance will allow minor problem to persist and may significantly reduce energy production. Some systems may be wrongly installed and operate below expected performance for years before this is picked up. Others may develop minor problems which are not corrected, dramatically reducing energy production.

When large numbers of small systems are installed in new urban developments and then left with ordinary householders to operate with no professional back-up there are particular risks that poor performance may not be picked up. PV UP-SCALE has focussed on large scale urban developments and has been able to look at the lessons learnt from the larger developments installed in the past and how those lessons are being applied by the developers and builders installing PV on developments today.

Developers today are likely to have very limited knowledge and experience with PV. If PV systems are then passed on to householders with no knowledge of PV, no direct contact with the PV installers and no servicing and maintenance plan the opportunities for problems to be missed and energy production to be reduced are multiple.

This is particularly important for PV because it is not always obvious whether or not a PV system is operating as it should. PV systems operate silently and without movement. If a grid connected system has tripped out power is still available from the grid. The only way to tell if the system is working is to look out for warning lights or keep an eye on metering or monitoring data. If the operators do not know how to interpret this data problems may go undetected.

Information about the PV system will also need to be passed on if the building occupants change. The PV system is expected to last for over 20 years and occupants are likely to change in this time.

PV UP-SCALE has developed best practice guidance on how to ensure systems are designed, commissioned, handed over and maintained so that they are most likely to be kept in good operating order.

The recommendations particularly apply to the design and installation of PV systems in groups of houses or where PV systems are installed in buildings with no specific connection to renewable energy or electricity generation. In these situations extra care is needed to ensure the occupants are able to successfully operate the PV system on a long term basis.

With buildings such as schools or care homes it is important to make sure someone at the building "takes ownership" of the PV. For example at one site in Kirklees there was a fault showing on the display panel because one of the inverters was down however it was not noticed or reported for some time. An operator's handbook was available however there had been personnel changes since the system was installed and no maintenance personnel reside on-site.

The situation is different if someone has made an individual decision to purchase and install a PV system. In that case they can be expected to have some understanding of the system, the quantity of electricity expected to be produced, the guarantees available and contact information for the supplier in the event of problems. But issues may still arise in later years if the house is sold. Providing maintenance information and contact points in a study format is still recommended.

The projects which have reported the greatest ease of operation and lack of problems have been systems operated by professional utility personnel. For example the NieuwSloten project in the Netherlands. Here the PV system is owned and operated by the utility NUON. The householders own the houses, but not the PV system. The electricity generated is used within the district but is not linked directly to the house on which it is mounted. Three different system concepts were considered for this project:

a. 1 system per house: 100 individual systems
b. 1 system per block of houses: 6 systems
c. 1 system per district: a single 250 kWp system.

Option c was chosen in order to minimize the costs of inverters, installation and maintenance. The system is monitored online. In order to ensure the safe operation of the installation and be able to follow it at a distance, three indicators are placed in all switchboards (DC- over voltage protection (varistors), DC- isolation control of the invertors, and a smoke alarm). The system has been trouble free to operate and has not involved utility personnel in extra work.

In Gleisdorf in Austria a number of PV systems were installed as part of a municipal programme. The PV Power plant installed on the roof of the Utility Company has been working very reliably and there have been very few problems reported. Service activities are carried out by the employees of the utility company. Function control is checked monthly and once a year the modules are cleaned. In the winter the surface of the PV modules is kept free of snow. The expected annual yield of 9000 kWh has been exceeded to 9500 kWh.

However projects where utilities are responsible for operating individual systems on houses have had more mixed results. For example the Nieuwland project in the Netherlands had an experimental Performance Guarantee & Maintenance System, but after some years this did not work out. In general the maintenance system was not stimulating a high performance of PV, as REMU collected the problems and did once a year some maintenance. Maintenance had to be done both regarding the roof integration which had some problems, and also regarding the technical quality and performance of the PV. During 2003-2007 maintenance was done on a minimum level; and the Performance Ratio went down quite a bit. The tenants have some understanding of PV as the communication by REMU and the Municipality from 1997 to 2000 was excellent. Nevertheless if a system was not or badly functioning, nobody notices unless the roof is leaking.

There have also been some problems where ownership of utilities has changed and the sense of ownership of the PV projects has faded.

Recommendations

During the **design stage** the designers need to consider how the performance of the system will be checked. A visual display is needed so that occupants can see whether or not the system is operating correctly. Simpler systems may just have an operating light and a fault light. More complex displays also provide energy production data. Energy production data can tell you if the system is operating as it should, however this is only effective if you have some idea how much energy should be being produced! Providing feedback to occupants on energy use and energy provided by the PV system can result in extra energy savings and is recommended.

The display needs to be in a location where it will be seen by the person responsible for ensuring correct performance. The display must give information in a way that can be understood by the operator. If displays are not sufficiently clear problems may not be picked up and no incentive to save energy is provided.

A connection to a remote monitoring service may also be provided. Some systems have a simple warning light system on site and more comprehensive data collection and display system available else where via a remote monitoring system. The correct solution will vary depending on the type of system and who has responsibility for operating it. There are commercial solutions offered in Europe that provide remote monitoring, yield and performance check (error detection routines), with the aim of reducing costs by optimizing energy yields and system maintenance. By making use of advanced Information Technologies and satellite solar radiation data, the user can be informed quickly of the PV system malfunctions.

The design also needs to allow for easy access for maintenance. Access to individual properties for maintenance or repairs can be an issue; locating inverters in communal areas is one way around this problem in apartment or flats buildings.

At the end of the **Commissioning and Handover stage** the completed systems should be handed over to the eventual occupants in full working order, commissioned and grid connected.

During commissioning it is important to check correct operation and administrative set up including:

- PV system output – ideally this should be compared to expected output although this will require knowledge of irradiance levels. Alternative methods such as comparing the outputs of different strings can also be used. Appropriate monitoring methods are described in the standard IEC 61724 (Photovoltaic system performance monitoring - Guidelines for measurement, data exchange and analysis), although currently work is being done at an international level in order to modernise the existing guidelines and better adapt them to the latest PV systems.

- Grid connection – Ensure export tariff agreed and contracts signed if needed
- Ensure electrical commissioning has taken place according to applicable regulations and permission to grid connect given.
- Visual display – check working correctly and understood by operator.
- Monitoring system – check working correctly.
- Responsibility for checking performance may need to be specifically allocated.
- Arrange insurance.

Clear operating and maintenance instructions must be provided including:

- Operation and maintenance leaflets in a sturdy format.
- Information about expected power and yields.
- A point of contact that can reliably answer any queries and organize maintenance.

At some new housing estates, developers have been keen to include PV to boost their green image but have not given sufficient thought to explaining the systems to the occupants. The new occupants may have no knowledge of PV before moving into their new house and no particular interest in the system so long as it works. Correct operation needs to be checked and commissioning done by the developer or their representatives. In addition all the paperwork needs to be complete, especially any paper work regarding grid connection. This can be very complicated and should not be left for private householders to complete. In some countries the paper work for connecting a small PV system is similar to that for connecting a large generator!

Once the systems are handed over the owners tend to be left to organise **maintenance and operation** by themselves. PV systems are low maintenance and easy to operate. Unfortunately this is sometimes interpreted as meaning they need no one to keep an eye on them. They may be good but nothing is perfect or lasts forever without some assistance. A maintenance plan is needed which includes consideration of:

- Who will be responsible for keeping an eye on the system? Do they understand how they visual display works? Do they know how much energy they are expecting to be generated and how to check it?
- Who can they contact in the event of problems or queries? Providing the telephone number of the standard utility helpdesk is not sufficient if the person answering the call is not going to be able to answer the query.
- How to transfer information in the event of personnel changes/sale of the house.

It is also beneficial to consider how to foster a sense of pride in the sustainable aspects of the area or building. The visibility of PV can be very useful here. For example in La Darnaise, the first renewable powered district in France PV is considered the flagship of the project. The social impact of this visible element of the urban regeneration is considered to be very valuable.

Groups of houses occupied by social housing tenants can be very successful but it does require some care and forethought. The housing association can keep an eye on the condition of the

PV systems, act as a central contact in case of queries or problems and organize maintenance and repairs.

Housing Association tenants need to know something about their PV systems. In Kirklees the housing associations prepared leaflets and the installers explained the systems when they were installed. The systems have been particularly successful at estates with a stable population and involved tenant representatives. Follow up can be done during a monitoring programme, for example at the Fernside solar village in Kirklees monitoring is done manually with a project officer visiting the houses on a monthly basis and noting meter readings. At the same time they can answer questions or concerns. At other estates the tenants have changed fairly frequently leading to a poor understanding of energy issues with those tenants who were not there when the system was first installed. A tenant information sheet is now included in all new tenant packs.

Fernside solar village in Kirklees, photo D Munro

People have to have a reason or incentive to maintain their interest in the performance of anything they own. If there is no reason to keep an eye in something it will eventually fall into disrepair. If the financial value of the electricity generated is low and there is no inconvenience suffered if the system is not working, and no pride in the sustainability of the building the result is likely to be poor performance in the long term. Financial incentives linked to generation, such as enhanced feed-in tariffs, provide an incentive for an owner to check performance occasionally and take action if problems are noticed.

One possibility for ensuring the successful long term operation of PV systems is to use an Energy Service Company (EsCos) to operate and maintain a group of systems. This has not yet been tried at many locations and there is limited data available but it is seen as a way forward for some situations. The company would have a commercial incentive to maximise energy production and responsibility for holding information on the systems. Checking performance and organizing maintenance would be part of their role.

The PV demonstration programme on municipal buildings in Barcelona has not yet found a successful model for maintenance. The possibility of using an EsCo is now being considered. At the moment maintenance of energy installations in public buildings is done by the General

Services departments at the district level. The existing work load of these services, together with the special characteristics of PV installations compared to conventional electrical ones has led to problems with the maintenance of the PV systems. Energy Services Companies are already being introduced for the management and maintenance of Solar Thermal Systems, a more developed market than PV in Barcelona.

The most risky time in a project, when there is the most likelihood of failing to do something, leading on to later problems, is when responsibility for the PV system is being passed from one person to the next. For example if systems are handed over to occupants without proper commissioning and information transfer or during changeover of occupants when information can easily be lost. If these risk points are considered when setting up a project it should be possible to keep PV systems operating successfully for many years.

Further information can be found in the case studies.

- Case studies with examples of utility involvement in the operation of systems include: Gleisdorf in Austria, Nieuw Sloten and Nieuwland in the Netherlands and Jvosai Town in Japan.
- Case studies with private developers include Kirklees and Barrow in the UK, and Hauts de Feuilly and Lyon Confluence in France.
- Case studies with Housing Association experience in operating PV system include: Kirklees in the UK, La Darnaise in France, Gleisdorf in Austria and Nieuw Sloten and Nieuwland in the Netherlands.

7. The PV UP-SCALE case studies

The urban areas studied in PV UP-SCALE were divided into 2 groups. The first were areas which had already installed significant amounts of PV. PV UP-SCALE reviewed the process by which they had got to this stage and the issues encountered on the way. Some of these areas had over 10 years of experience with PV to review and lessons learnt covered all stages from the initial idea of the project to maintenance and system performance.

The second group concerned urban areas new to PV and involved preparing plans for the inclusion of PV in future developments at sites in France, the UK and Germany.. The initial concept was that these plans could be virtual plans with little probability of realization. However PV UP-SCALE succeeded in locating areas where new developments were being planned and the option of including renewable energy was of serious interest. The plans developed are all being taken forwards in some manner. For this group the PV UP-SCALE case studies are only able to give a snap-shot of the progress made in the 2 years PV UP-SCALE has been running. This is a very short time scale compared to the time that may be taken to develop and occupy a new area. The case studies therefore focus on the planning and design stage, rather than implementation and occupation.

Reviews were carried out of PV projects in::

1. Grand Lyon - La Darnaise (France)
2. Grand Lyon - ZAC Hauts de Feuilly (France)
3. 5 MWp Urban PV-project "City of the Sun" in the HAL region, (the Netherlands)
4. Nieuwland (the Netherlands)
5. Nieuw Sloten (the Netherlands)
6. Freiburg - Schlierberg Solar Estate (Germany)
7. Croyden/Merton (UK)
8. Kirklees (UK)
9. Gleisdorf (Austria) – city of PV Projects and other renewable energies
10. Barcelona (Spain)

Plans to incorporate PV in the future were developed for:

1. Grand-Lyon ZAC Lyon-Confluence (France)
2. Barrow waterfront development (UK)
3. Cologne-Wahn (Germany)
4. Berlin (Germany)
5. Gelsenkirchen-Bismarck (Germany)

Each case study is briefly described here; in addition the full case studies can be downloaded from www.pvupscale.org.

Grand-Lyon, La Darnaise

The conurbation of Grand-Lyon in central France has been active in the area of renewable energy for some years. One of the earliest projects was the installation of PV facades during the refurbishment of high rise buildings at La Darnaise. This area had a very bad image due to urban riots in the past. PV became part of the strategy to change the image of the area. The reputation and image of the area was successfully transformed to a renewable area. PV provides a visible symbol of the transformation of the area.

Initially, renewable energy sources were not part of the refurbishment plan for La Darnaise which concentrated on the installation of external insulation and low-emissivity windows. But in 2001, the local energy agency organised technical visits to renewable energy systems. The technical visit on PV was to a multi-apartment building with a 10 kWp PV system. This initiative led to the modification of the project to include renewable energy systems.

La Darnaise PV façade: Photo credit ALE agglomération Grand-Lyon

Hauts de Feuilly

More recently the Hauts de Feuilly housing development, also in Grand-Lyon, has been designed as a sustainable development with high levels of energy efficiency and renewable energy systems. It is currently being constructed to meet environmental guidelines proposed by the Grand-Lyon Community. The experience gained during this project was used by the Grand-Lyon Community to improve the local energy guidelines and to increase energy efficiency in buildings and the use of renewable energy systems above levels required by national regulations.

Hauts de Feuilly housing development, photo Hespul

Stad van der Zon (City of the Sun) in the HAL region of the Netherlands

Complete new urban districts are currently being built in the HAL region of the Netherlands, approximately 40km north of Amsterdam. The HAL region contains the municipalities Heerhugowaard, Alkmaar and Langedijk who each have high ambitions with regard to quality of building, quality of living and above all energy and CO_2 reductions. An ambitious project is underway to install a total of 5 MWp as part of these new developments split between:

- Heerhugowaard "City of the Sun" 3,6 MWp (on-going, completion end of 2008)
- Alkmaar 1 MWP (realized in 2003)
- Langedijk 0,4 MWp (realized in 2004)

This massive project is inspirational but also proving very challenging to complete. Projects on such a large scale take such a long time to be implemented they can be unwieldy to steer and vulnerable to changes in government policy. Despite changes in government policy and the loss of expected funding the project continues. The continuation of the project is partly down to the involvement of all stakeholders in the HAL consultative body: municipalities, province, energy supplier, ECN and consultants.

Nieuwland

In the Waterkwartier district of the Nieuwland expansion area of the city of Amersfoort, the worlds' largest complete urban PV project was realized in 1999. The municipality of Amersfoort initiated the project together with the local electricity utility company REMU. The project has been widely quoted and visited as a demonstration of urban scale PV. However policies to support renewables in the Netherlands were dropped by the national government after the project was implemented so the experience obtained by developers and architects on the implementation of PV has seldom been called on.

The project consists of over 500 houses, schools and sport facilities with 1.3 MWp of PV modules integrated into façades and the roofs. Solar optimization was taken into account in the urban planning phase with the land being parcelled out to provide as many roof surfaces as possible suitable for the installation of solar panels. All the urban planners, architects and developers involved were required to co-operate in the implementation of the solar power project. An information centre was established in the city district with PV buildings. This centre was co-operated by the electricity company REMU and the municipality and a coalition of real estate developers active in the district. Studies of consumers' energy awareness and behaviour have been carried out.

Nieuw Sloten (the Netherlands)

The Nieuw Sloten PV houses project was one of the first PV projects installed at an urban scale worldwide. In this project PV was installed on houses in a new housing area. The project was led by the local electricity utility, the Energy Company of Amsterdam (now NUON). It was an important demonstration of PV in urban areas and helped to pave the way for later projects.

The houses were completed in 1996 so there are now 12 years of experience from the project. This case study looks at the lessons learnt since the project was started. A separate pdf describes the development process and the organizational lessons learnt.

Gelsenkirchen

Gelsenkirchen is a former industrial city in Germany going through a structural change. Known as the city of 1000 fires (coal mining) a new sustainable mission (city of 1000 suns) was created to support the structural change. As part of this mission the City provides and supports:

- Local agenda network (energy and environment)
- Climate protection at schools (information and implementation)
- Solar urban planning
- Energy consultancy
- Installation of solar systems on communal buildings
- Solar round table
- Website

The mission has led to economic and education benefits for the city.

Now a solar quarter is planned on derelict land from a former power station, close to a waterway. The area will include residential and office buildings, trade, commerce and recreation with high requirements for energy efficiency, solar urban planning and applications of solar systems. The quarter is predicted to include 2000 working places and 700 dwellings. In an innovative approach the city is imposing solar requirements in the contract of land purchase.

Freiburg

Freiburg is said to be Germany's ecological capital, with ecological standards for new developments being applied nearly 20 years ago. There is a high level of political commitment to renewables with many people living in the area enthusiastic and knowledgeable about renewables. The long standing ecological reputation of Freiburg has led to economic benefits for the city with many institutes based there. The city and the Schlierberg Solar Estate have won environmental prizes.

Even for Freiburg the "Solarsiedlung am Schlierberg" (Schlierberg Solar Estate) has ambitious energy targets. On an annual basis its buildings export energy. They are highly energy efficient buildings with an annual heating demand below 18 kWh/m² (Passive house standard). Additionally, all roofs are covered with PV modules. The whole development was privately funded with an innovative share scheme. It was initiated and pushed by the architect Rolf Disch.

Croyden

The London Borough of Croyden was one of the first municipalities in the UK to implement the "Merton Rule". The Merton Rule is a new planning policy, pioneered by the London Borough of Merton, which requires the use of renewable energy on-site to reduce annual CO_2 emissions in the built environment. Croyden Council adopted the rule which requires all proposals for non-residential developments exceeding 1000 m^2 gross floor space, and new residential developments comprising 10 or more units, to incorporate renewable energy production to off-set at least 10% of predicted carbon emissions. This rule applies to both new build and conversion for residential developments, and is in addition to meeting requirements for use of energy efficiency under the Building Regulations. The first project designed to reach the 10% target was completed in July 2005, and since then a further 11 projects have been completed. Out of these projects, seven have incorporated PV, with the most notable example being the integration of 39.4 kWp of PV on three new residential blocks at the Queen's Hospital site.

The main barrier for developers is seen as know-how not cost. Croyden Energy Network's Green Energy Centre provides advice and support to developers with accessing grants and suitable renewable technologies to use.

Kirklees

Kirklees Metropolitan Council, in the North-West of England was one of the first municipal authorities in the UK to promote the widespread use of PV on buildings within their urban area. The first projects undertaken were within the EC funded SunCities project. This led to the installation of 400 kWp of PV, mainly on housing, within Kirklees. The SunCities project was followed by other renewable projects within the area including installing PV on council buildings and schools and projects designed to promote renewables to local residents.

There has been a strong commitment to renewables in the local council backed up by a dedicated Environment Unit able to advise and assist with implementation of renewables projects. Targets have been set for the implementation of renewables in the area and obligations may be imposed on developers to include renewables in major new developments. The economic benefits of the renewables policies have been assessed and quantified and the impact on residents' energy consumption studied.

PV on saw tooth roofs, Kirklees, Photo D Munro

Gleisdorf

The Solar city of Gleisdorf lies in the Austrian province of Styria. Within Austria Gleisdorf is known for its numerous renewable energy initiatives, projects and measures. Since 1991 many new PV and solar thermal systems have been installed with over 150 different projects in different locations. A Communal PV power plant on the roof of utility Feistritzwerke-Steweag was the first PV power plant in Austria realised through a shareholder programme.

The city government takes positive measures to support renewable energy in the city and works closely with the utility "Feistritzwerke". The city government has made a decision that in the future PV-plants, solar thermal plants and biomass must be installed in all public buildings constructed. For private building owners there is an obligatory free consulting interview with a representative of the utility company for everyone who wants to plan a new building. The actions of the municipality have been recognized by various national and international energy-awards and environmental protection awards.

Solar wheel for school in Gleisdorf

Barcelona (Spain)

Barcelona City Council is a pioneer municipality supporting energy sustainability. In 1998 a political decision was made to promote energy sustainability through the use, amongst others, of renewable energies. It was the first European city to develop a Solar Thermal Ordinance (1999) making it compulsory to use solar energy to supply at least 60% of hot water demand in all new buildings, renovated buildings or buildings changing their use. In 2000 the first integration of PV in buildings was realised (Barcelona City Council building), since then an increasing number of projects have been carried out, both in public and private buildings.

Lyon-Confluence

Following on from successful earlier projects in the Grand-Lyon area PV is now being included in a major development site at the heart of Lyon on the peninsula formed by the Rhône and Saône, Lyon's two rivers. Lyon-Confluence is the name of the southern part of this peninsula. It has for a long time been given over to industry and transport logistics but is now undergoing a radical change. Major development projects here over the next 30 years will double the area of Lyon's city centre.

Renewable energy and sustainable development are now important elements in the development but this was not originally the case. PV UP-SCALE documents the changing perception stakeholders had of PV; from an initially poor image, where PV was considered to be not relevant to high density urban areas and not adapted to the high architectural quality of the project, to a final more open opinion where PV is acknowledged to be an easy technology to deal with and suited to large scale urban projects.

An informal group of local experts was set up in order to help define the energy strategy. The CONCERTO call for projects launched in 2003 by the European Commission was of great help: As part of the CONCERTO project, a team of local specialists was set up to assist engineering offices and developers at all stages of the project, from the preliminary design to the commissioning of PV systems. This local team also organised site visits and training sessions and will help developers in dealing with a complex financial scheme with multiple sources of funding.

Barrow

Barrow is a city on the North West coast of the UK in the region of Cumbria. The city was a major ship building centre, however ship building has been in decline in the UK for a number of years, leading to a decline in the prosperity of the city. Major redevelopments are now on-going including a plan to develop a large part of the waterfront adjacent to the docks. The developments to include a marina, housing village, water sports leisure area, wetland wildlife area, business park and cruise terminal. The transformation of the under used and partially derelict dock locations into a modern, sustainable development has the potential to transform the city.

A development brief for the site has been developed by the local regeneration organization with PV UP-SCALE providing information on renewables. This includes obligations to achieve sustainable building standards and to install sufficient renewables on site to provide a minimum of 10% of the expected energy demand. This will be the first major sustainable building development in the area. Priorities in the area tend to be focused on economic regeneration and environmental concerns have not been high on the political agenda.

Cologne-Wahn

Close to the Centre of Cologne but in a rural area a new solar housing estate is planned. Cologne-Wahn is a formerly independent village around the castle of Wahn. Now it is part of the City of Cologne. The landowner of an estate close to the castle plans to build a solar housing estate with around 180 dwellings.

This project is not so much due to policies of the local municipality as to a subsidy program of the state of North-Rhine-Westfalia for solar housing estates. The program has specific requirements for active and passive solar energy including either 1 kWp of photovoltaics per dwelling or a share of 60% of DHW generation by solar thermal systems.

The landowner decided he was willing to invest in the development of a solar housing estate and invited 8 well-known architects to realise an urban plan consistent with solar requirements and building types fitting in the concept of solar housing The work was embedded in the scope of an official architectural competition.

Berlin

The fall of the Berlin wall led to development opportunities in the centre of Berlin. The municipality commissioned a solar urban master plan for the City in order to determine the solar potentials of the different city quarters. An analytical solar planning process was performed where 20 types of city quarters were identified each with a solar potential determined by their history, structure and utilisation. Specific areas were selected as high priority areas for solar development. This assessment has now been combined with an urban renewal program and a PV campaign is planned to inform building owners of the possibilities of PV and motivate them to invest in PV.

The municipality's role is limited to the provision of information and encouragement. No obligations are imposed and the municipality is not responsible for the design of new developments which are the responsibility of owners and developers. However robust analytical data, with information on shading and potential outputs is provided to potential investors.

8. Top tips at various project stages

Policy Stage

- Build political commitment at all levels, national to local.
- Add to policy framework; stimulate to have short, medium and long term goals.
- Put resources into a dedicated environment/sustainability department if department exists, if not create one!
- Use obligations and incentives.
- Provide free information and initial assistance to help get projects started.
- Arrange visits and tours.
- Feedback results from positive projects to policy makers (environmental, social, visual and economic benefits) to create a positive cycle leading to strengthening of policy.
- Ensure positive results and awards publicized.
- Learn from problems with earlier projects.

Project start-up

- Take solar energy into account in urban planning as early as possible.
- Talk to all relevant stakeholders. Especially talk to the DNO about possibilities as early as possible (if not facilitated by law).
- Emphasize synergy where possible – PV as shading device, construction material, image builder.
- For existing buildings explore synergies with retro-fit measures (roof tiles, insulation etc)
- Identify the value the different stakeholders see in PV and the different information needs for each stakeholder. Architects may want design specifications while engineers may want energy production specifications. It helps when these differences between stakeholders are identified in an early stage of the project.
- Include renewables in site *brief* from the beginning if possible.
- Require proof of relevant PV experience in design team.
- Define what stage the system is when handed over (technical and contractual) i.e. commissioned and export contract signed or earlier stage?
- Require plan for informing/training rest of design team with some basic understanding of PV and implications for them.

Raising funding

- Consider all possible options (regular and innovative):
    - Subsidies
    - Income from electricity , feed-in tariff
    - Loans
    - Sponsors

    - Solar funds and share schemes.
- Consider cost savings from combining functions (e.g. PV also proving shading).
- Consider the balance needed between complexity and effort required to raise funding and benefits potentially obtained. Having multiple sources of funding can make for complications.
- Timetables of funding and construction must be compatible.
- Consider who is eligible to claim the various funding options (from occupants to municipality to installers).

Design stage
- Take passive solar design and energy efficiency into account during the whole design process.
- Future proof (allow for the future addition of renewables) e.g. roof structure with identified fixing locations or provision of identified and accessible electrical cable ductwork.
- Follow design guidance, available from many *sources.*
- Consider guarantee periods required and form of guarantee (components, system and energy output).
- Ensure clear lines of responsibility, guarantees of roof, PV, etc.
- Consider the range of building integrated PV styles available and choose the look wanted from highly visible design feature to invisible.
- Design to maintain output over the life of the system (facilitate easy maintenance, system checking and monitoring).
- Consider end of life safe dismantling and recycling.
- Match complexity of system and level of effort required to keep operating to prospective occupants.

Construction/realization
- If the project is innovative for the region ensure that design and construction are well done with the help of a PV expert.
- Safety guidelines need to include PV.
- Use experienced/trained installers.
- Co-ordination between contractors and installers is vital.
- Plan PV mounting process within building process.
- Minimize risk of damage to roof or PV during installation by installing together.
- Just in time delivery of modules minimizes risks of damage or theft.
- Arrange a safe storage location for modules and insurance.
- Uncertainty/risks increase costs so provide information to other contractors to avoid cost mark ups due to concern about delays or unforeseen problems.

Handover
- Ensure information is provided to occupants (sturdy format), including guarantee documents.
- Ensure interface/display confirming PV operation is available and understood by user (visual signal for operating/problem and electricity generation data).
- Ensure electrical commissioning has taken place and permission to grid connect given.
- Ensure export tariff agreed and contracts signed if needed (in Germany some feed-in contracts may be worse than the default conditions required by law).
- Ensure maintenance plan in place and well documented and filed.

- Arrange insurance.

Operation

- Foster pride in the sustainability of the area.
- Information needs to be passed on if building occupants change or technical personnel change, consider if a formal procedure is needed.
- Provide information about expected power and yields to allow poor performance to be detected.
- Providing good metering and feedback to occupants helps to keep them aware of energy saving and can result in extra energy savings.
- If displays are not clear problems are not picked up and incentive to save energy not provided.
- Responsibility for checking performance needs to be with someone.
- Reliable point of contact for queries and maintenance needed.

Risk point – initial planning

- Initial urban plan not solar aware.
- Not in brief so nobodies problem.
- DNO not aware when installing electricity supply network and so not strong enough or not enough supply points = extra costs to refit.
- Incompatibility of funding and development timetables.

Risk point - handover

- Handover to occupants without export contracts signed, paperwork difficult for householders to deal with.
- Changeover of occupants and information lost.
- Lack of output and nobody notices or has sufficient incentive to fix.
- Income needed or no incentive to keep operating.

9. Summaries of the national planning process

Photovoltaics are installed within a complex framework of regulations, funding arrangements and planning policies. The framework not only varies between countries but also between provinces and even municipalities. In general the framework is designed to promote the use of renewable energy, including photovoltaics, and to reduce carbon emissions. However with national, regional and municipal governments involved and different departments responsible for different parts of the framework the general result can be somewhat fragmented with a general trend towards the promotion of renewables but with some policies and regulations working against the general trend and having negative impacts on the implementation of PV.

The main elements of the framework that impact on PV are:

- Building regulations
- Codes for "Green buildings"
- Capital subsidies for renewable systems
- Enhanced feed-in tariffs for renewable systems
- National, regional and local planning policy for renewable systems

Building regulations exist in all countries; generally they are neutral regarding their impact on the installation of PV systems, covering such topics as structural safety and insulation levels. However they can be used to require the installation of renewable energy systems. In Spain many larger buildings are now required to have a PV system (this includes: commercial buildings, showgrounds, offices, hospitals, clinics, hotels and hostels) and all buildings are required to have a solar thermal system. In Germany, the building regulations give credit for renewable systems that generate thermal energy, but not for electrical generation systems such as PV. This tends to encourage the installation of solar thermal systems which receive credit under the building regulations, instead of systems that generate electrical renewable energy such as photovoltaics.

Codes for "green buildings" are available in many countries. In contrast to the compulsory building regulations which have to be applied to all buildings these are optional. They tend to give credit for the installation of photovoltaic systems and can be an important driver for the inclusion of PV system in buildings. For example in the UK the Code for Sustainable Buildings credits PV systems and other renewable systems. A minimum Sustainable Buildings rating is now often required by funding bodies that may support regeneration projects or the construction of social housing. This is an important driver in the renewables market in the UK.

Capital subsidies for PV systems are not as common as they were and have been replaced by feed-in tariffs in some countries. Capital subsidies through competitive grant application mechanisms are still available in the UK through the Low Carbon Buildings Programme and in local and regional schemes in Austria, Germany, France and the Netherlands. An income tax credit system is also available to private individuals in France.

Enhanced feed-in tariffs for photovoltaic systems are available in Spain, Germany and France which provides a premium rate for all PV electricity. The German Renewable Energy Sources Act (EEG) assures a fixed feed-in-tariff for grid-connected solar electricity over a time span of 20 years. Via the feed-in-tariff (currently ca. 46 cent/kWh, depending on the kind of system) the investment in a PV-system can be recovered during its lifetime with a reasonable return on investment. A limited feed-in tariff based support system is also available in Austria, but it has a limited budget so that only the first few applicants receive funding.

National, regional and municipal planning policy for renewable systems. Planning policies promoting renewable energy tend to be developed, at least at the detailed level, at a municipal or regional level. This may or may not link to a national planning policy for renewable energy.

- In **Austria** there are no nationwide directives for the use of RES in the urban planning process or any rules or targets which set a certain percentage of electricity generation from RES for new buildings. Municipal bylaws may include planning requirements to increase energy efficiency of new or retrofit buildings and/or the use of renewable energy sources.
- In **Germany** local authorities may define urban areas where solar energy should be used based on a national legal framework. It is up to the local authorities to use the legal possibilities to realise urban planning with a focus on a solar development. The City of Marburg is about to launch the first solar obligation concerning thermal systems. This has caused some legal complications and controversy.
- In **France** there is no specific national policy to encourage the use of Renewable Energy Sources (RES) in the urban planning process. In response to this lack of national policy, some local authorities have implanted local policies. For instance, Greater Lyon, drew up on a voluntary basis a local policy to enforce the Rational Use of Energy and the use of RES in new buildings.
- In **the Netherlands** the emphasis in the urban planning process is with the municipalities. City Councils prepare structural plans which provide details of how to transform national and provincial policy into concrete plans. This leads to the development of an urban design which may prescribe energy performance, sustainability aspects, etc.
- In **Spain** land use legislation and energy planning are the responsibility of the Spanish Regional Governments called “Autonomous Communities” (AC). Within each AC, urban planning is developed at a local level by the Town Councils. The General Urban Distribution Plan is the main tool for urban planning in Spain. Once developed and approved by the Town Council, the proposal must receive the final approval by the Government of the AC, in order to come into effect. Regional legislation depends on the Regional governments (Autonomous Communities). For example, in the case of Madrid’s AC, the Energy Plan 2004-2012 aims at doubling the energy contribution from Renewable Energy Sources and a 10% reduction of CO_2 emissions. Amongst the actions foreseen related to Photovoltaics, the promotion of PV systems in domestic and services sectors, and the support of municipal bylaws are mentioned. In September 2005, there were more than 30 municipal bylaws concerning solar technologies, most of them only dealing with

Solar thermal. The region of Catalonia is by far the most active in this field, followed by Madrid and Valencia.

- In **the UK** a National Planning Policy Statement specifies the encouragement of renewable energy at a local level. In response local authorities draw up Local Development Frameworks. There is an increasing trend for authorities to include renewable energy rules in these. A typical rule is that all new large developments (10 or more dwelling or > 2000m2) must generate a percentage of their energy requirements from on-site renewables, percentages range from 10% - 40%. This is one of the main drivers in the installation of renewables in the UK at present.

Further information on the planning polices and regulatory frameworks in each of the participating ***PV UP-SCALE*** countries are given in the pdf documents which can be downloaded below:

- The Austrian planning process
- The German planning process
- The French planning process
- The planning process in the Netherlands
- The Spanish planning process
- The UK planning process

Further information on the economics of PV is available from the economics section of ***PV UP-SCALE*** and from the IEA PVPS Programme which produces an annual report on Trends in Photovoltaic Applications (look under international statistics) which includes a review of the latest policy and regulatory framework for deployment. National reports with are also available from the IEA web site under Country Information.