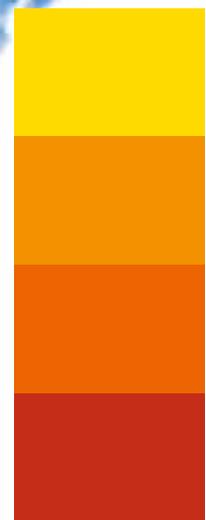


Identification and mobilisation of solar potentials via local strategies



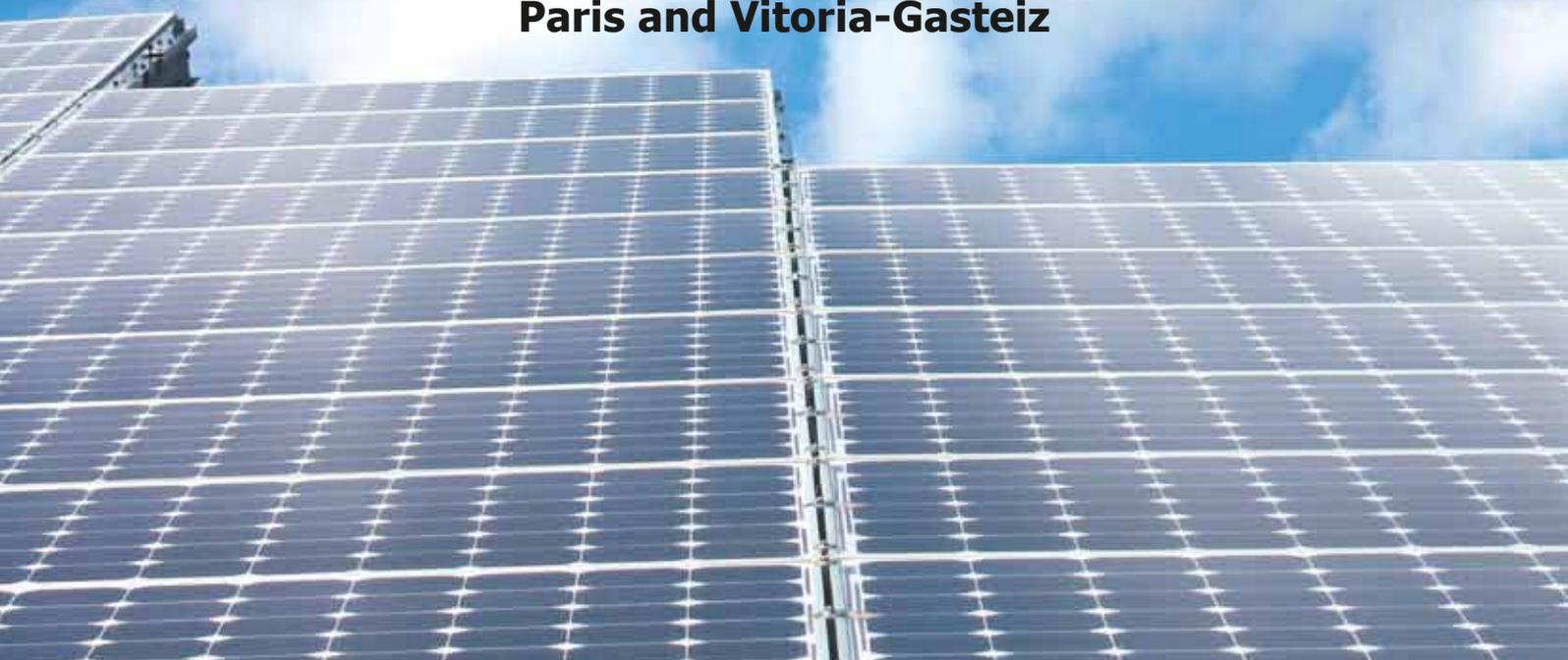
Guidelines

based on the experiences of the pilot actions

in

Lisbon, Lyon, Malmö, Munich,

Paris and Vitoria-Gasteiz



Imprint

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What is solar urban planning?

Energy consumption is becoming increasingly concentrated in cities: today they are home to almost 80% of the European population, giving rise to 75% of the total energy demand and CO₂ emissions. We also know today that we are nearing the end of the era of cheap (fossil) energy, that reducing energy demand must be placed at the top of our agendas, and that the energy supply of the future will not come from big power stations but rather from a multitude of small and decentralized plants – increasingly powered by renewable energy sources!

Cities and municipalities are therefore among the most important actors when designing the energy future of Europe. Hence in addition to working intensively on saving energy and becoming more energy efficient, they face the challenge of realising the potential of the various energy sources available locally and deploying policies to take advantage of these. Producing energy locally is not only a strategy for securing the energy supply and creating regional value, but also for influencing the entire production and consumption concept, reducing losses in the energy distribution network, and also calling for new storage systems and schemes to manage supply and demand.

With the aim of increasing the share of locally produced energy from renewables, awareness of (the opportunities of) renewable energy technologies must be increased via information and communication, and local authorities' interest boosted. The municipality itself assumes the role of designer of the whole policy, which includes the definition of targets for renewable energy production and the creation of instruments promoting the integration of such technologies from the very beginning of each new urban planning process. Legislation is crucial, though the cooperation with real estate promoters, urban planners, engineers and architects is just as important. Direct interaction with the market should also be encouraged, reinforcing the need for new approaches, methodologies, technologies and materials.

Within the portfolio of renewable energy technologies, solar systems have the unique potential to be merged directly into the urban environment, transforming cities into huge, diffused green energy production facilities. Due to the large variety of forms and functions, solar panels (photovoltaic and thermal) have exceptional properties for being used in all kinds of buildings and urban structures. This being said, the shape of building structures and relevant surfaces is decisive to both the active and passive solar yields. More than any other renewable energy source, solar energy is therefore closely linked to the form, function and arrangement of buildings, and consequently requires careful planning procedures, which take these special requirements into account.

Solar systems can also play a role in the existing building stock however. In order to harness this potential, new techniques and instruments have been developed for its analysis. This includes laser-scanned surveys of roof surfaces integrated into geographic information systems or methodologies to evaluate pilot projects within the context of the actual urban structure typology.

As early as 2002, the potential for PV development in existing buildings was considered as Task 7 of the International Energy Agency Photovoltaic Power System Programme (IEA-PVPS-Task 7). A set of thumb rules were developed indicating, for instance, that every square metre of floor space required 0.4 m² to be available to incorporate in solar technologies, particularly photovoltaics. So, why not use the figures already available and evaluate the effective potential to integrate solar technologies further into cities, putting research and demo projects into practice, and implementing such integrated strategies in the field of urban planning?

The POLIS project

POLIS – identification and mobilisation of solar potentials via local strategies was a European project co-funded by the Intelligent Energy – Europe (IEE) programme aiming at the implementation of strategic urban planning and local policy measures to activate the solar ability of urban structures in European cities. With diverse new technologies and legislative opportunities having recently been developed to perform solar potential analyses and harness the solar potential identified, the aim of the POLIS project was to present and evaluate current developments, and to bring key stakeholders together in the process to improve planning and legislation practices towards solar development.

The POLIS project brought together local authorities from France, Germany, Portugal, Spain and Sweden with different experience and varying states of urban development to share their expertise on solar urban planning and encourage further activities within the scope of an expert network for cities. The main project outcomes were:

- 1. Action plans:** long-term strategic action plans to integrate solar energy at the urban level embedded in overall planning strategies of the POLIS partner cities of Lyon, Paris, Munich, Lisbon, Vitoria-Gasteiz and Malmö.
- 2. Pilot actions:** a total of 19 short-term actions developed in the partner cities within the project lifetime, such as the identification of solar potential, accomplishment of activities to mobilise potential identified, development and implementation of urban planning measures, financial and/or legislative measures.
- 3. Transfer of the POLIS approach to other cities:** lessons learned and experiences from the POLIS project were described and evaluated as background for the development of planning references and legal guidelines. Together with the provision of a catalogue to promote urban planning instruments and best practice projects, these guidelines represent a major project outcome.

The vision of the POLIS project partners was to jointly support the establishment of excellent framework conditions for the implementation of small-scale renewable energy plants in the participating cities with a road map for further activities in the field of solar developments. In the long term, this will help in the implementation of the EU and national targets for renewable energies for 2020 and beyond as well as in the provision of interested cities of all EU Member States with a pool of successful examples, strategies and instruments.

Details of all outcomes of the POLIS project can be found at: www.polis-solar.eu.

The composition of the POLIS consortium guaranteed an interdisciplinary approach: local energy agencies, universities, consultancies, urban planning agencies and municipal planning departments provided a broad background of expertise from the diverse fields of specialisation, as well as different perspectives and ways to approach the planned activities.



How can these guidelines help you?

Based on experience gathered during the pilot actions in the cities of Lisbon, Lyon, Malmö, Munich, Paris and Vitoria-Gasteiz, these guidelines were developed to support you in adaptation of your urban planning procedures with the aim of boosting solar energy in your city or town.

The POLIS partners have identified a total of ten guidelines necessary to implement a coherent planning policy in favour of solar energy. They address how to identify and mobilise the solar potential, optimise solar urban planning processes, and adapt local policies and legislation.

Each of the ten guidelines (covering the entire process from data collection to policy development and legislation), solar urban planning tools and practices, and participation of citizens will help replicate these successful experiences in other cities, benefitting from the lessons learned in practice.

All the guidelines are presented in a standard format. They:

- ▶ provide a short description of the background and general approach,
- ▶ propose concrete methods and instruments,
- ▶ offer tips on necessary local conditions and which partners to involve,
- ▶ highlight financial aspects,
- ▶ analyse success factors as well as risks and barriers,
- ▶ specify necessary input, results and outcomes,
- ▶ describe – wherever possible – the impact on greenhouse gas emissions, and
- ▶ refer to lessons learned during the POLIS pilot actions.

The POLIS partners hope that these guidelines can support you in your commitment to develop and implement solar urban planning strategies for your city or town, contributing in this way to a more sustainable and “sunny” Europe.

1. Compiling the data

Background and general approach

Assessing the solar potential of a district or even an entire city, as well as defining urban layouts with solar optimisation tools is based on a whole variety of data. A central challenge is therefore how to compile the necessary data i.e. about the city cadastre, the three-dimensional structure of buildings or the statistical weather conditions impacting solar yields.

The city cadastre is owned by the local authority responsible for the development and updating of these data. In some cases, the data used in the city cadastre comes from an aerial flight that can be performed together with the Light Detection and Ranging (LiDAR) data collection. Creation of this model is complemented with a photographic assessment, which is essential to validate the model results.

LiDAR data and GIS cartography are usually provided by the local authorities or other public agencies. This source data can be used for transformation into the Digital Elevation Model (DEM) of the city by means of Geographic Information System (GIS) software.

Methodologies and tools

The basis for all planning processes is up-to-date data on the city cadastre. More precisely, vector information about blocks and buildings is required, which allows extracting data for the buildings of a selected area to be analysed. A DEM of the city (at least 50 cm per pixel) and GIS map detailing all buildings in the city are required for all calculations. GIS software facilitates management of a large quantity of georeferenced data.



Therefore an aerial flight on which to base the DEM is very important for evaluation of the solar potential of cities. The LiDAR methodology constitutes one possibility to develop a local digital surface model. With this model, it is possible to identify each roof's slope, orientation, shadowing effects from neighbouring buildings and other architectural obstacles, and to combine this with data on diffuse and reflected irradiation so as to assess each building's annual available solar irradiation.

Additional information about parameters to install solar energy systems on top of incident radiation (building preservation orders, structural conditions, minimum surface available, socio-economic data, etc.) are necessary for evaluation of the solar potential.

! Look for recognised national institutes, municipality cadastre departments and data collected locally. The reliability and validity of the base data is crucial to the results achieved and their usefulness. Remember that evaluating potential is a tool to deploy and foster new market mechanisms, so the results need to be valid and the possibility to develop new functionalities based on this service kept open.

As for the climate data, the most reliable data should come from the national meteorological institute, though this can be complemented with specific data compiled by a specialised research institute.

The identification of listed historic buildings where the patrimonial/architectural value of the building prevents the installation of solar technologies is also relevant information, as are specific local legislation and guidelines from general urban development plans, for example. National and local ordinances – solar or otherwise – can also reveal important information related to solar urban planning.

! There are different sources of data with varying degrees of quality and usefulness. The first step is to identify the feasible and reliable sources. The next are to compile the available data, analyse their compatibility and validate the data between the different sources to ensure reliability of results.

Other data such as structural conditions, estimated domestic hot water consumption or thermal envelope features can be derived from the legislation applicable at the time the buildings were constructed.

Apart from data collection, an important step is to analyse the available national and local legislation (urban or technical), ordinances and cartography.

Inputs and necessary local conditions

Institutional support is crucial to ensure the necessary input data for solar urban planning. This is evident, for instance, with regard to data in the city cadastre providing more precise blocks and buildings vector information, which allows for the extraction of data solely for the buildings in the area to be analysed.

It is also very important that the technical team and the municipality collaborate from the very start of the project. The municipal workers afford in-depth expertise about their city and can easily provide the technical team with the necessary information. Or, in other words, without the municipality's help, locating this information could be an extremely time-consuming task for the technical team.

Adaptation of the methodology to the GIS used in the local municipality is preferable. The reasons for this are:

- ▶ spatial and non-spatial data can be linked to city maps;
- ▶ multi-criteria analyses can be performed to assess the urban solar potential;
- ▶ GIS software facilitates the management of large quantities of georeferenced data;
- ▶ the results obtained from GIS-based software are shown in digital maps, creating useful information for urban planners.

If realistic data about the energy consumption of buildings is available, energy balance analyses can be performed. Furthermore, compatibility with GIS allows for relationships to be established between energy and socio-economic data. The result is a powerful tool for decision-making in urban design and renovation.

And, last but not least: apart from the generation of data as a first step, it is necessary to ensure a permanently updated database to monitor future urban development.

Success factors and frequent barriers

It is important to have time resources available for data acquisition in a complex and broad planning process. While data compilation, the testing of different tools to use existing data and the evaluation of results are often very time-consuming, they result in a more detailed level of input data for the subsequent solar potential assessment. The necessary time frame varies considerably depending on the partners and the effective availability of data. It should not take long for the municipality to obtain the information contained in any official document (local or national). It could take longer to develop specific information such as LiDAR data or specific cartography such as GIS cartography containing height data. At least two months should normally be reckoned with for the compilation of all data.

Incompatible data formats of private software products are a frequent barrier to the exchange of data and a potential risk. It is therefore advisable to use open-source software with standard open data formats.

Another frequent barrier is the fact that the city cadastre information normally relates to buildings and not to other structures such as bridges and non-building structures affecting the solar availability of the surrounding surfaces due to shadowing effects. This must be acknowledged in the results or dealt with during data compilation to ensure that additional cadastre information is provided and included from the outset in definition of the DEM.



Main drivers and stakeholders

When a local authority wishes to assess the solar potential of a city or district, they must be committed to the project, as it is the entity to which the most important data is available as well as the one to effectively apply the use of the solar potential analysis in urban planning and management tools.

The municipality and other public agencies should provide the technical team with all available information, which could be needed for the solar urban assessment.

The entity responsible for contracting the solar potential development should also be the one to compile all the necessary data.

Different city departments have spatial data that is important to solar planning. An easy exchange of data between these departments is of course a necessary local condition for success.

Financial aspects

The aerial flight with LiDAR data collection is the most expensive data needed for the solar potential assessment. The costs for the flight depend on the area to cover, the urban landscape and density, as well as at the level of detail of the photogrammetric flight.

Other data, namely building cadastres, can be made freely available by the local authority or purchased from the national geographic institute (or similar) for a nominal fee.

Impact on city targets for CO₂ reduction

Once the solar potential of a city or area has been identified, results can be presented not only in terms of the surface available for solar technologies according to the incident radiation, but also complemented with estimates on how much energy these surfaces would produce if solar technologies were installed. For this purpose, data on energy consumption per energy source/carrier must be collected to estimate the potential contribution of photovoltaics and solar thermal collectors. This data can be calculated by building, according to the building typology (i.e. services, industrial, residential), number of inhabitants, occupancy rate, etc., or for the entire city, considering the overall demand and the impact the use of solar technologies would have.

POLIS experiences and lessons learned

In **Lisbon**, the data collection process for the development of the solar potential analysis took place in cooperation with the municipality and took roughly two months. Due to administrative constraints at the municipal level, the aerial flight already available for the city's area had to be purchased from the company responsible for its development, which delayed the process somewhat. The cadastre, namely the blocks and buildings vector information, was provided by the municipal cadastre department, as georeferences compatible with GIS for each building.

The following methodology was used in **Vitoria-Gasteiz** to calculate the CO₂ emissions and impact of solar energy in the residential and commercial sector:

- ▶ obtain energy consumption data from the different utility companies (electricity, gas);
- ▶ obtain details of the Spanish electricity production mix showing the shares of energy sources and fuels used (renewables, coal, oil, gas, etc.);
- ▶ use this data to calculate the CO₂ equivalent emissions using the emission factors of each type of fuel (source: Buwal 250, 1998) for the different sectors of the city;
- ▶ verify the impact of the actions envisaged in the "Plan to Fight Climate Change in Vitoria-Gasteiz 2010–2020" related to solar energy by using the above figures and comparing with the total sector target.

2. Identifying the solar potential at city level

Background and general approach

Solar potential analysis at a macro level began with Task 7 of the International Energy Agency's Photovoltaic Power Systems Programme (IEA-PVPS-Task 7), which was dedicated to the architectural and technical quality of PV systems' installation in the built environment. One of its most important outcomes was the definition of a first methodology to estimate the solar potential of a building based on the country's building culture and architecture as well as on foreseen architectural constraints/barriers. This first methodology enabled a preliminary overview of urban solar potential based on existing building and town structures – so strategic promotion of the consideration of solar technologies at the local level. The main goal was to determine the expected contribution of solar energy in the national energy mixes so as to define policy, strategies and incentives for solar technologies accordingly.

The evaluation of cities' solar potential:

- ▶ raises politicians' and policy makers' awareness and interest in solar technologies, allowing them to define targets for the city's and associated policies based on a real assessment and clear identification of the solar potential in their city;
- ▶ enhances awareness among citizens of the potential and opportunities for solar energy;
- ▶ boosts investors' interest in specific projects;
- ▶ sensitises town planners to the opportunities created by solar energy;
- ▶ creates a common platform for citizens and investors to communicate and develop new business models to realise the potential identified.

Solar potential evaluation is usually promoted by the municipality or local energy agency. It must be an instrument developed in the municipality's interest and in cooperation to ensure the availability of the most recent data on territorial analysis and the inclusion of results within solar urban planning tools. The first step is therefore the active involvement and political commitment of the local authority to promote the solar assessment and cooperate in the gradual analysis and evaluation of results.

- ! The evaluation of the solar potential of cities
 - ▶ can be an important market stimulant for the identification of new investment sites and business models, and
 - ▶ is crucial to vitalise the renewable energy sector, raising awareness and promoting the adoption of solar technologies in the most favourable locations.

Once the commitment is made, the methodology needs to be defined based on available inputs and budget before the assessment is performed. It is important to keep the contracting entity involved during the entire process to validate the results and ensuring that the final product complies with the requested analysis. Validation of the work should count on city experts, namely technicians from the urban planning department due to their detailed knowledge of the city's fabrics, to help identify irregularities or unexpected results due to specific local conditions. Depending on the interaction between the development team and the contracting entity, the solar potential assessment is expected to take about 4–6 months, though this also depends on the presentation of results.

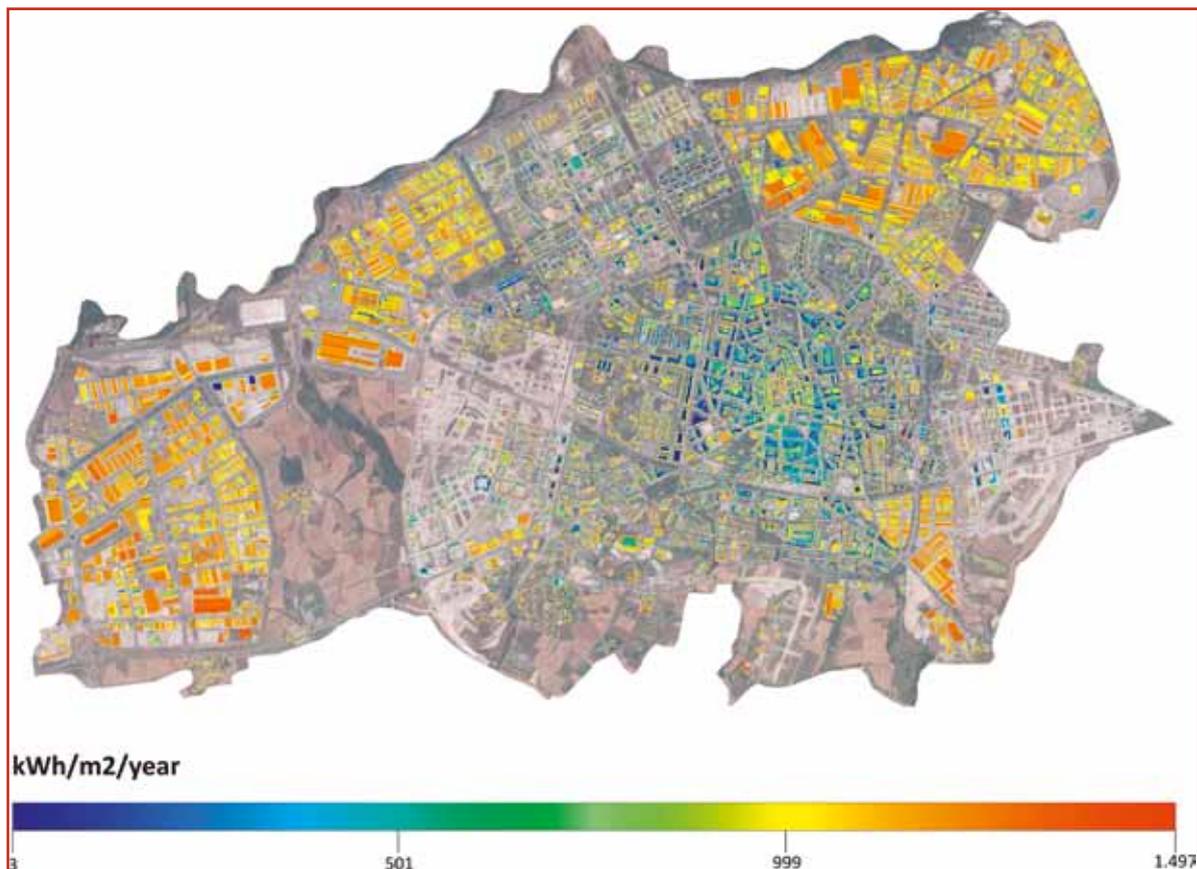
The decision on how to present the results depends on the primary objective of the assessment. It can be an instrument to be included in regular urban planning activities used to raise awareness of the public, or a policy/market instrument to be used by politicians for the adoption of new strategies to promote solar

energy. It is essential to understand each target's requirements and the best way to present the solar potential to successfully promote its use. An interactive presentation is one of the best ways to engage people in use of these new functionalities, namely through visualisation maps using Google Maps, Bing and other available programmes. Further combination of this data with other relevant data on the city climate and urban development can be an interesting further step.

Methodologies and tools

A possible methodology to develop solar potential maps is the use of aerial flights with LiDAR data. This input data allows for definition of the surface's altimetry through the creation of a DEM. This model is adjusted to the building cadastre and consists of a grid with data on the orientation and slope associated with each point of intersection. Once it has been created, a GIS solar analysis tool should be used to determine the incident radiation on the buildings, taking into account the specific solar parameters for the local analysis and the shadowing effects of the neighbouring areas, which can reduce the surface's solar availability.

Other parameters such as structural data, listed building preservation orders and available surfaces should be considered in order to identify limitations to the installation of solar energy systems. The final maps should not only take the incident radiation into account, but also other parameters specifically detected for each urban area.



It must be easy for non-technical stakeholders responsible for the mobilisation of solar urban potential to understand the resulting maps. And finally, the municipality must design an appropriate campaign to disseminate the results obtained, showing not only the urban solar potential, but also the economic and environmental benefits when this potential is exploited.



Please also see Guideline 5 on the mobilisation of citizens

With respect to tools for identifying cities' solar potential,

- ▶ the availability of LiDAR data and up to date building cadastre information is a key pre-condition to create a DEM of the city;
- ▶ the combination of a DEM and solar analyst GIS software is an adequate methodology for large areas due to the high level of process automation;
- ▶ it is essential to select a dynamic tool to present and ascertain the solar potential.

The GIS tools currently available on the market allow for a global understanding of available solar radiation, which was not the case a few years ago. For instance, it is now possible to establish the relationship between different urban fabrics and the associated solar potential as well as between building typologies and solar availability. Therefore a typological review of the buildings is needed. This assessment is different for each city, though construction typologies and methodologies can be identified and subjected to the same assessment criteria. The typological review is necessary to determine the practical constraints of panel installation.

Inputs and necessary local conditions

Starting points for evaluation of the solar potential of a city are:

- ▶ up-to-date digital cadastral information about the city's buildings;
- ▶ an aerial flight with GPS/INS data – should the methodology be based on creation of a DEM (at least 50 cm per pixel);
- ▶ an aerotriangulation project for the aerial flight;
- ▶ availability of an image database to evaluate/validate the results;
- ▶ definition of the coordinate system for the output.

Every effort should be made to offer an as detailed as possible solar potential assessment by taking advantage of the most recent cadastral documents and the technical advances in the use of the LiDAR methodology. This is because it is an opportunity to explore and properly evaluate the richness in terms of solar availability to optimise investments and stimulate the market.

The necessary time frame can vary significantly due to different factors such as the size of the town/city, parameters considered or source data provided.

Success factors and frequent barriers

The main objective of the solar potential assessment is to kick-start local initiatives for solar developments. However, it could also form the basis for the local authority to determine requirements related to solar energy in ordinances and other legislation. An effective dissemination campaign must therefore be designed to communicate the project outcomes with the aim of encouraging stakeholders to install solar energy systems.

The greatest impact is generated using solar potential analysis by combining the illustrative information with other applications on a public website (information about costs, income from the feed-in tariff, local companies installing panels, etc.). If a hotline is provided, investors seem to be even more motivated to install photovoltaic and solar thermal devices.

Please also see Guideline 5 on the mobilisation of citizens

Barriers to the evaluation of the solar potential of cities are:

- ▶ decision-makers not understanding the importance and added value of solar potential identification, and therefore not promoting this evaluation or committing to its use;
- ▶ the present financial situation in Europe and worldwide that leads to a reduction in the incentives for renewable energies in general and solar energy specifically, which may hamper investments in solar potential studies;
- ▶ technicians at the local authority level not having the capacity to utilise the solar potential assessment as an effective tool for urban planning and management;
- ▶ a lack of solar energy experts able to collaborate with the local authorities in the integration of solar urban planning criteria based on solar potential assessments;
- ▶ a lack of cooperation/interest with/from the solar industry market in using the solar potential map as a first assessment for a new project and preliminary contact with a client;
- ▶ a lack of information about parameters related to the possibility of installing solar energy systems different from incident radiation (building preservation, structural conditions, minimum surface available, etc.).

External risks for a successful evaluation and utilisation of the solar potential of cities are:

- ▶ a lack of political commitment, and
- ▶ the non-existence of a national or local strategy to deploy renewable technologies, namely solar.

Main drivers and stakeholders

Analysis and planning tools will not be enough to mobilise the potential identified and boost solarisation in the urban environment. However, an improved information policy about potential and active involvement of local stakeholders (citizens, urban planners, architects, municipalities, etc.) applying the developed results will make the difference.

On a political and institutional level, it is important to have:

- ▶ political commitment to set specific goals regarding solar potential, and to define strategies and supporting policies;
- ▶ institutional support for evaluation of the solar potential (input data, relevant urban and energy laws and ordinances);
- ▶ market support to benefit from the results and mobilise resources to respond to the forthcoming interest arising from potential evaluation.

Financial aspects

Solar potential evaluation is a huge step in the definition of a city's relationship with its solar resources. The identification of the solar potential by means of a DEM requires the pre-existence of an aerial flight

from which the solar potential can be drawn based on existing GIS tools such as GRASS, ArcGis and others. Of all the required inputs, the aerial flight is without question the costliest. Therefore, synergies should be formed by combining aerial flights performed at the municipality's expense for the geographical cadastre.

In general, costs for this activity depend on the city's surface area as well as on the quantity and quality of the necessary input data to create the DEM.

The effective added value of the city's solar potential analysis to the mobilisation of the identified potential needs to be coordinated with the solar market so that these actors can benefit from this instrument to raise awareness among citizens, investors and other relevant stakeholders. The market actors are essential partners in the sharing of costs for this evaluation, and are – together with the municipalities – direct beneficiaries of these studies, as they allow them to evaluate business opportunities and to exploit these via direct contact with the owners of the areas with the highest solar potential.

Main results

The assessment of a city's solar potential is an essential tool in definition of the city's energy strategy, as it allows for targets to be set and policies to be defined based on a quantified analysis of the potential role of solar technologies in the city's energy matrix. This assessment can and should be detailed by means of a financial study to determine the best business models to associate with the development strategy, establishing incentives based on the expected productivity, associated investments, return periods and exploitation models.

As a communication tool, the creation of solar potential maps for the entire city can be explored in great depth since they presents a strong image of a city's capacity to make use of its own resources, raising awareness among the city's stakeholders – from the policy makers to the market actors and individual citizens. Such an initiative is able to create a substantial interest on solar technologies, and to encourage the organisation of local initiatives.

Impact on city targets for CO₂ reduction

The identification of a city's solar potential allows policy/decision-makers to elaborate development strategies and to set performance targets based on real data. This is crucial for an explicit definition of measures to which direct results and impacts can be associated. At present, when mayors commit to challenges such as the Covenant of Mayors where the definition of quantified measures is critical to the overall commitment of reducing local CO₂ emissions by 20% until 2020, it is essential to identify which measures are most appropriate for the respective city. Energy efficiency plays a key role in this task, followed by the adoption of renewable energies that can make a huge contribution to reducing CO₂ and other GHG emissions at the local level.

Solar policies can contribute to both: to energy efficiency through solar urban planning and solar passive housing, and to renewable energy production, where each kWth or kWh produced can be quantified in terms of the CO₂ emissions avoided. The contribution of each energy unit depends on the national or regional/local energy mix.

POLIS experiences and lessons learned

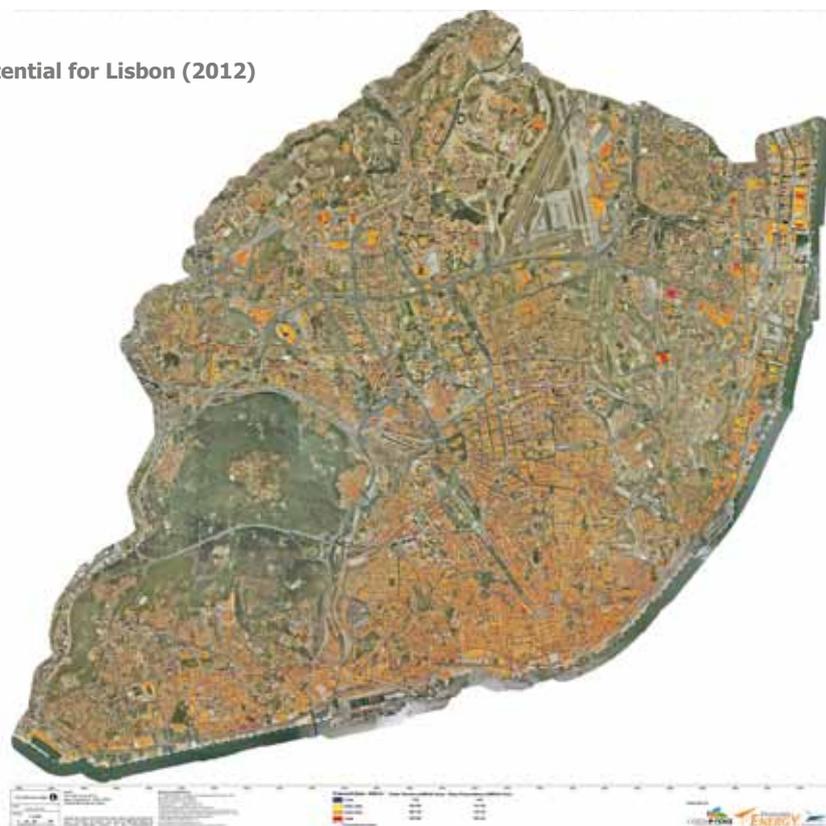
In **Lisbon**, evaluation of the city's solar potential included more than 60,000 buildings. The results show that 28% of all roofs are ideal for the installation of solar technologies with annual available radiation of more than 1,600 kWh/m² (mostly south-facing roofs with a slope of around 30°). This assessment is just the first step towards understanding the effective potential of each building, which must be assessed together with the building's structural capacity to host solar systems and the building's typology to identify the adequate technologies to use according to the building's function. Integrate solar technologies harmoniously into the city's building stock is the architectural challenge.

As a result of its pilot action, the city of **Paris** gained a comprehensive overview of the solar potential for 80,000 buildings. As flat roofs were assumed in the calculation, a consecutive slope calculation of the individual roofs will be necessary to ascertain the real potential. This is planned for 2013. A typological review of the buildings is needed to determine the constraints to the practical installation of panels. For now, the local authority focused on the identification of flat roofs, as these are the ones with immediately available potential, but also with less stringent restrictions regarding building preservation orders. They shall be used as preliminary demonstration projects to encourage commitment to solar energy.

In **Vitoria-Gasteiz**, the method applied allowed for a broad spectrum of analysed scales: from a city-wide overview to individual buildings. This approach involving different scales was the strongest point of this POLIS pilot action. Efforts were specifically made to analyse each roof, providing a very precise picture of the solar potential. In the future, the workflow must have a higher level of automation. This is a priority due to the huge amount of elements analysed on the city scale.

Three-dimensional cartography such as a DEM should be developed from source data. This kind of cartography is a key factor to attain the desired level of automation. Two-dimensional cartography with a high level of detail is important to show citizens the optimal part of a roof for installing solar energy systems.

Map of solar potential for Lisbon (2012)



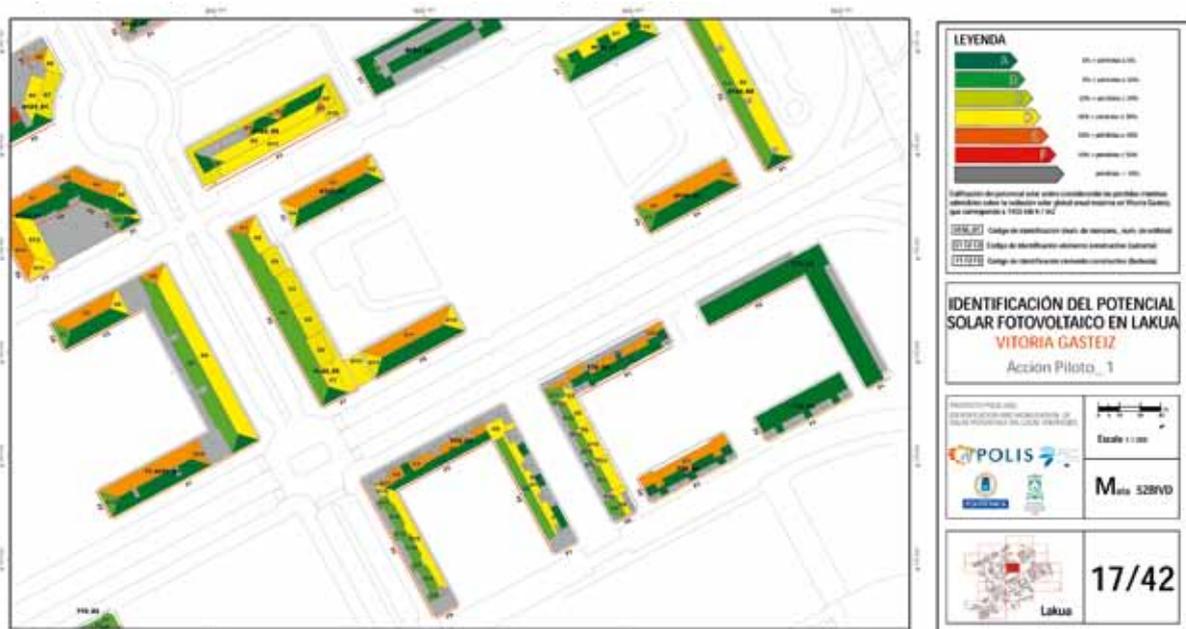
3. Identifying the solar potential at building / district level

Background and general approach

The concept of eco-neighbourhoods and sustainable districts arose more intensively in the beginning of the twenty-first century with the Beddington Zero Energy Development (BeZed) project in London (UK). This iconic urban development brought the importance and possible accomplishment of sustainable districts to the urban development discussion: it sought to reduce inhabitants' energy demands and to base their energy production on renewable technologies so as to reduce the impact of urban lifestyles overall. To successfully achieve this, the assessment and integration of solar technologies was indispensable as an element in the integrated approach to the area's energy needs, but also as a building component – from solar architecture to the active solar technologies that could be embedded in the building. Furthermore, the recent directives from the European Commission on near zero energy buildings address solar technologies as the priority technology to integrate into the building's envelope as an active part of building construction. This is not only the case for new buildings but also for refurbishment work where solar systems can be integrated into the existing buildings, performing a wider set of functions than mere energy production.

The potential for solar energy at building and district level can be calculated and analysed using 3D models for the buildings. These:

- ▶ raise citizens' awareness of solar energy and its potential;
- ▶ boost investors' interest in specific projects;
- ▶ create interest in increasing the use of solar energy also among city planners.



Therefore, evaluation of the solar potential at a district or building level is:

- ▶ an urban planning instrument when defining district requalification goals and possibilities;
- ▶ an essential tool in definition of the requalification project for an existing area/building;
- ▶ also a crucial tool in the evaluation of existing buildings where the energy consumption patterns are known so that the solar contribution can immediately be forecast given the existing needs (electricity and domestic hot water);
- ▶ potentially an important market stimulant;
- ▶ very important to vitalise the renewables sector.

Requalification plans for existing areas should firstly address the area's needs and priority intervention axes, and then define solutions exploiting the available resources. When identifying the need for a requalification plan, several studies need to be accomplished by the local authority to identify the specific background conditions. Solar evaluation of the area is one such study and should constitute a pillar in definition of the intervention guidelines, addressing solar passive techniques and local energy production means. This analysis can be performed as the overall analysis for the city (with LiDAR data, **see Guideline 2**) or simplified via characterisation of the existing area and buildings, requalification needs and available surfaces.

Methodologies and tools

The first step is to compile all the existing data for the area/building. The appropriate methodology needs to be selected on the basis of the available data – and existing financial constraints.

High-detail cartography (including height data) must be provided to analyse each building element (roofs and facades). The incident radiation on the building elements is calculated taking the losses due to elements' orientation, tilt and shadowing as well as structural data, surface available and preservation orders into account.

To calculate the active solar potential (photovoltaic and solar thermal), the global annual radiation and – for calculation of the passive solar potential – the direct solar radiation during the underheated period are estimated.

Source data (cartography, buildings data, etc.) must be provided by the local authority. The technical partner must design and implement an appropriate methodology adapted to the specific situation in the area in question (local legislation, structural data, climate data, preservation orders, etc.).

As a next step, a climate analysis must be performed to identify the underheated period, and from this, the global annual radiation and the direct radiation during the underheated period calculated.

The **photovoltaic solar potential** is calculated for both roofs and facades.

The **solar thermal potential** is only calculated for roofs. To estimate this potential, domestic hot water and heating production objectives are set for each building according to their use, size, number of residents and thermal envelope's characteristics. Information about the number of solar collectors needed to provide the solar annual fraction fixed must be calculated (f-chart method).

The **passive solar potential** is only calculated for facades. The direct solar radiation falling on these facades is estimated during the four hours around solar noon (from 12 to 16) for the underheated period and is therefore different for each city.

The building elements have to be studied thoroughly on a case-by-case basis. As a result of this analysis, the active and passive solar potential is calculated and depicted in three different maps: photovoltaic solar potential, solar thermal potential, and passive solar potential.

With respect to tools for the evaluation of the solar potential of buildings and at district level it is essential to:

- ▶ integrate passive solar intake/input including facades potential;
- ▶ consider the building's structure and effective capacity to support the solar systems (i.e. minimum areas for solar thermal);
- ▶ assess the facades' potential;
- ▶ associate a dynamic tool to present the results of the solar potential evaluation.

 **Appropriate tools can be found in the "planning instruments" section on the POLIS website.**

Inputs and necessary local conditions

Development projects should meet stringent quality criteria in terms of urban planning, architecture, environmental impact and landscaping. One important aim is to introduce energy considerations (consumption and renewable production) in the first phases of the urban planning process. Solar potential identification at building and district level based on detailed information about building structure is an important task to achieve this aim.

If this is the first area for a potential analysis, the main effort should be to develop a feasible method, including the testing of different programmes and different kinds of input data to ascertain the most efficient approach for making the best use of the existing spatial data available from the local authority's planning department.

At a political and institutional level, it is important to have:

- ▶ political commitment, and
- ▶ institutional support for the evaluation of solar potential (input data, relevant urban and energy laws and ordinances).

The necessary time frame varies depending on the size of the respective area and the complexity of the urban morphology. This complexity is translated into a shadowing study – a highly time-consuming task.

Success factors and frequent barriers

The greatest impact using solar potential analysis is achieved by combining the illustrative information with other applications on a public website (information about costs, income from the feed-in-tariff, local companies installing panels, etc.).

External factors crucial to success include:

- ▶ interest from private investors;
- ▶ interest from the solar market;
- ▶ investment capacities, namely through attractive investment partnerships with banks;
- ▶ attractive financial support, namely by feed-in-tariff mechanisms.

Risks to successful evaluation and realisation of the solar potential of districts/buildings are:

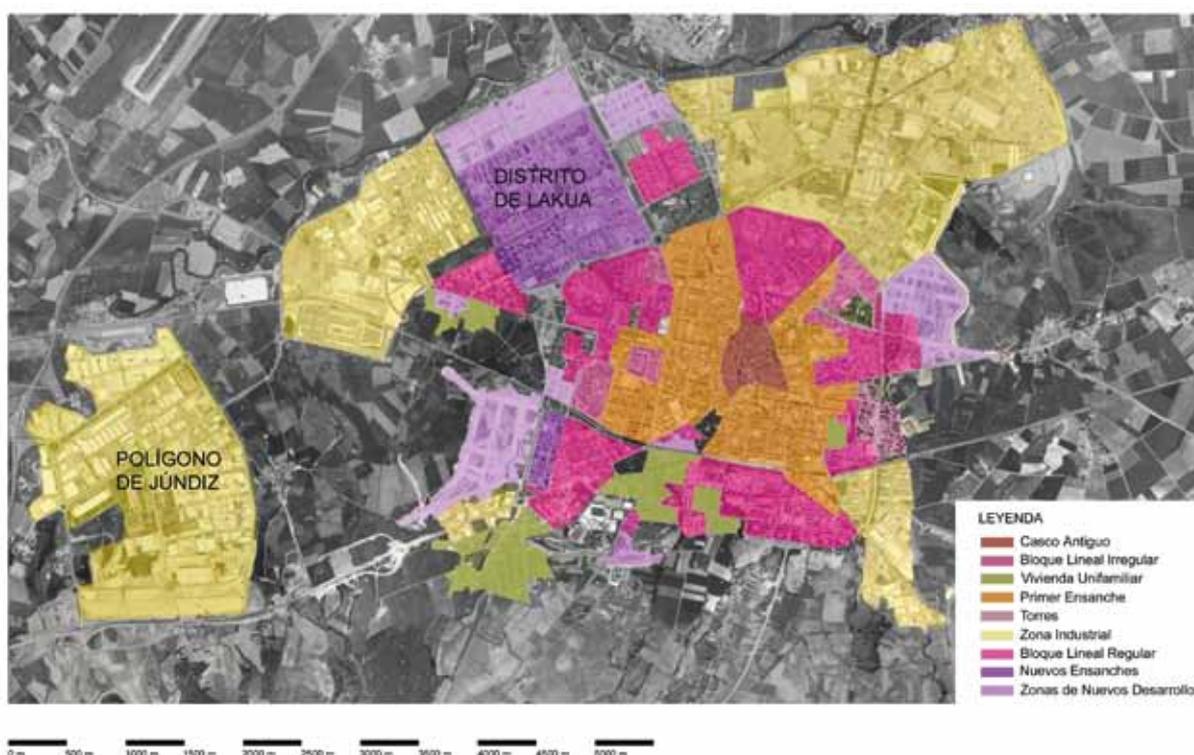
- ▶ a lack of political commitment, and
- ▶ the non-existence of a national or local strategy to deploy renewable technologies, namely solar.

Main drivers and stakeholders

Analysis and planning tools will not be enough to mobilise the identified potential and boost solarisation in the urban environment. However an improved information policy about potential and active involvement of local stakeholders (citizens, urban planners, architects, municipalities, etc.) applying the developed results will make the difference.

An effective dissemination campaign must therefore be designed to communicate the project outcomes. This would encourage stakeholders to install solar energy systems.

The results achieved are to be presented to the various stakeholders involved in the requalification process to critically comment the results and define the most appropriate methodology given the area's specific conditions.



In the case of requalification plans, the local authority is the one to promote the necessary evaluations. Nevertheless, the initiative may also come from private stakeholders wishing to promote solar technologies or apply for the area's requalification plan via an urban competition.

As for private buildings, the solar potential evaluation should take place at the start of refurbishment project definition, as the solar systems could be embedded in the building and can therefore drastically change the building's concept.

Financial aspects

At the district level, efforts for this activity will depend on the approach and level of detail, as well as on the area's size and complexity, meaning that the costs may vary significantly. In general, costs will depend on the district size (surface), as well as on the quantity and quality of input data necessary to obtain the 3D information of the district.

Given the more practical character of this evaluation, the assessment must also consider a pre-evaluation of the buildings' conditions and the effective capacity to integrate solar technologies into existing buildings, namely through structural evaluation of the roof cover. Once the solar potential has been assessed, its effective promotion depends on the solar targets defined for the area and the political commitment for its exploitation. For private real estate companies to commit to those targets, they must either be compulsory – set by the local authority – or the local authority must grant economic advantages for their implementation, such as reduced taxes or construction credits for the real estate agent.

Main results

The instrument can be used for several purposes, namely to generate interest in the possibility of increasing the use of solar energy as well as to study different building areas to categorise areas according to their potential. The results should allow for the identification of urban planning guidelines focusing primarily on buildings' solar access, sufficient daylight availability, passive solar refurbishment needs and opportunities, and capacity to accommodate the respective solar technologies.

Technically, the main results of solar potential identification at the building and district level are:

- ▶ recommendations for solar passive refurbishment and new construction;
- ▶ solar thermal and solar photovoltaic potential assessment maps;
- ▶ a database with detailed information on the solar potential of each structural element;
- ▶ an accompanying document featuring a description of the methodology developed, its application and recommendations for mobilising the solar potential identified.

Possible impacts of solar potential identification at the building and district level are:

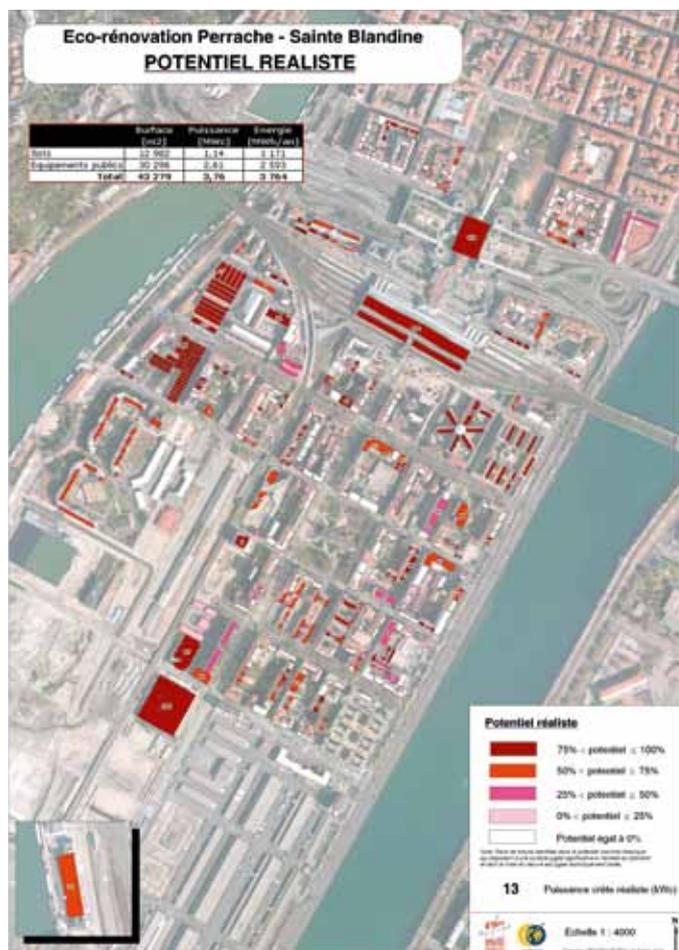
- ▶ to allow for the definition of an energy strategy for the district based on real potential and effective compatibility of resources;
- ▶ the possibility of defining legal requirements on solar energy adoption via solar ordinances, supporting schemes and incentives;
- ▶ to develop common awareness-raising instruments that are comprehensible for all relevant stakeholders (citizens, professionals and industry associated with solar energy and the construction sector).

Impact on city targets for CO₂ reduction

The evaluation of the solar potential at the district level can take a more practical approach than the one at the city level (**please see Guideline 2**). It allows for the detailed identification of buildings' potential and combination of the assessment with other studies at the building's structural level and effective capacity to technically host solar systems. This kind of detail is essential to define implementation strategies and ensure the development of pilot projects, which can stimulate development of the solar market and exploitation of these results on a wider scale.

POLIS experiences and lessons learned

As the experiences from the pilot action in **Vitoria-Gasteiz** revealed, calculation of the radiation loss due to shadowing is very time-consuming. For complex urban morphologies, a process with a high level of automation must be implemented.



Another pilot action in **Lisbon** was the evaluation of the solar potential in the Boavista district at the existing building level. This analysis was developed within the framework of a requalification plan for this district to become an eco-neighbourhood. The most suitable areas were identified and, after this preliminary approach, complementary studies considering the structural capacity of the roofs and the necessary safeguard perimeter in each roof were developed. This allowed to identify the effective, constructible solar potential for the neighbourhood as well as realistic targets for its exploitation and finally the prioritisation of the interventions according to the most appropriate/profitable areas.

The pilot action in **Lyon** on the potential evaluation in the Saint Blandine district also considered the potential of existing buildings and stressed the need to identify a systematic process to include a cross-check of the roof structures and their effective capacity to bear solar systems in the evaluation. Another issue still needing to be worked on is how to take the facades' potential into account.

4. Organising training for urban planners

Background and general approach

The effective adoption of solar technologies at the urban planning level depends on urban planning professionals' capacity and availability to perceive the added value of these technologies and their ability to integrate these in the most profitable way. The training of local authority staff on these topics would allow for integration of a systematic review of the opportunities for solar energy into each planning process. Such training would include units on the basics of individual technologies, the adoption process, the integration possibilities, etc. This would enable both technicians from the local authority and private professionals to gain expertise in these areas and to actively promote the implementation of solar technologies.

The organisation of solar urban planning training should cover a broad range of topics – from the national strategy and legal framework to solar urban planning guidelines, solar passive strategies and solar active technology principles to coordination of the conventional energy production and distribution infrastructure.

Aimed at urban planners or other professionals involved in urban planning, definition of the target audience is essential to establish the content and level of detail to each topic. Once identified, the content to address, the speakers to invite and the supporting material to distribute to the participants must be defined. Usually training should be complemented with tours to real cases to enable the practical examination of solar technologies. This is especially important when introducing active solar technologies, the planning needs and constraints, and how the arrangements imposed at the urban planning stage may hamper or boost the use of these technologies.

Possible options are for instance to organise either an intensive two-day training session or a more dispersed one on three afternoons or mornings, complemented by a practical on-site tour.

Cooperation with the local authority is essential to ensure its technicians' participation. This is of utmost importance for the training itself, as an audience with different backgrounds and professional experience should be aimed at, as sharing of experiences, asking questions and debating form part of the training.

Local energy agencies have the potential to organise this kind of training, as they have privileged contact both to the local authorities and to the market. This allows them to select the most appropriate professionals and to share their own daily work experience. The collaboration with the national solar industry association is also essential to ensure cooperation with the market side. Of course, other actors such as consultant companies or even the local authority itself can also organise such training sessions with the support of experienced local actors.

Methodologies and tools

The curriculum for such training could look as follows:

- 1.** Solar radiation and its use
- 2.** Solar urban planning
 - a. Concept integration in urban design
 - b. Integration into the energy supply networks
 - c. Design tools
 - d. Potential evaluation in the urban environment
 - e. Best practices
- 3.** Solar passive concepts
 - a. Direct solar gains
 - b. Indirect solar gains
 - c. Solar passive architecture
- 4.** Solar active: solar thermal systems
 - a. How a solar thermal system works
 - b. Solar thermal system components
 - c. Types of collectors
 - d. Heat storage systems
 - e. Solar circuits
- 5.** Solar active: solar photovoltaic systems
 - a. How a solar photovoltaic system works
 - b. Types of panels
 - c. Off-grid and on-grid applications
 - d. Integration into buildings
- 6.** Legal framework for solar systems
 - a. National/regional/local energy strategies
 - b. Legal requirements (energy certification systems, building energy performance, etc.)
 - c. National/regional/local incentives for solar systems (solar thermal incentives, micro generation, mini-generation, etc.)
- 7.** Solar thermal practical cases: dimensioning, installation, maintenance and servicing
- 8.** Solar photovoltaic practical cases: urban applications
- 9.** Relation to the electricity grid: decentralised electricity production, implications to the distribution grid
- 10.** Solar thermal systems and the natural gas network

Inputs and necessary local conditions

Training workshops on solar technologies and their integration into the architectural and urban design processes targeting local authority technicians and dedicated to architecture, engineering and urban planning activities are a good way of promoting solar urban planning and bringing it into daily work as the 'normal' way of planning.

The training sessions should address solar urban planning as well as solar passive and solar active technologies, and could involve also partners from other municipalities, experts and private participants.

An evaluation report compiles the feedback from participants, and is a good method to assess the further training needs.

Necessary local conditions for the success of such training for urban planners are:

- ▶ interest from the local authority;
- ▶ available best practices at the local level to enable more direct contact with the experiences in the area;
- ▶ availability of experts to provide technical support for the training;
- ▶ cooperation of public and private entities in the training to ensure a rounded perspective of the solar market;
- ▶ strong cooperation with the national solar industry association.



Solar Tours in Lisbon

Success factors and frequent barriers

The project should work on the organisation in different stages of the urban planning process. It should include the aspects of passive and active solar energy in different existing processes and instruments, and take the local legal and political background into account.

The training should focus on the various areas of solar technologies, urban planning, passive and active solar technologies to give an overview of all possible options, and should be combined with a tour during which trainees can familiarise themselves with realised projects.

Finally, an evaluation report should be considered to quantify the success of the training and obtain feedback from the participants.

Urban planning professionals should have an interest in the overall guidelines of solar urban planning. Sometimes they lack the competences to do so. Training would help them to understand the importance of these topics and the need for support from specialised consultants in this field.

Potential risks include a lack of:

- ▶ motivation among professionals;
- ▶ local legal context;
- ▶ political will to support the competence training of urban planners, architects and engineers.

Main drivers and stakeholders

The diversity of organisation structures and associated processes in the different municipalities makes it difficult to establish standardised methods and approaches. At the urban planning level, the diversity of topics that must be addressed makes the creation of interdisciplinary teams, which can cooperate and achieve integration between the different applications, indispensable. These interdisciplinary teams are to be mandated at the higher decision-making level to ensure political commitment and effective fostering of these initiatives.

Financial aspects

The most relevant costs when organising training are those related to the hiring of a training room and audio-visual equipment and to the transport foreseen for the on-site visits. Some speakers may require payment, but in some cases, i.e. if the speaker is from a company within the market or a research institution, partnerships can be established to avoid these costs.

The cost of the training for participants largely depends on the type of organisation promoting the training. Usually there are cooperation agreements with the local authorities to reduce costs for their technicians – by offering either the training room or even the transport for the tours. The participation costs for private professionals need to be commensurate with the training, content, number of hours and speakers.

Main results

Training workshops for professionals on solar technologies and solar concepts of urban planning are an important tool to implement solar urban planning on a permanent and systematic basis.

Study tours to solar installations and solar passive and active buildings provide practical experience on the advantages of solar housing and living.

The main target groups should be urban planners and researchers – including teachers, who can pass the message on to their students to foster the integration of solar urban planning concepts in students' curricula.

Impact on city targets for CO₂ reduction

As a consequence of the increased capacity of urban planners, solar urban planning will be applied systematically to each area to be developed or refurbished in the respective city/municipality, realising the potential in these buildings and areas.

POLIS experiences and lessons learned

During POLIS, Lisboa E-Nova, **Lisbon's** municipal energy environment agency organised two training sessions as part of its pilot action. One was organised as an intensive two-day training session; the other more dispersed in time, comprising three workshops, a conference and a solar tour. In total, more than 300 participants attended these activities.

The added value of the training was the cooperation with the solar industry association, the diversity of topics, and the experienced speakers addressing the relationship between renewables and the conventional energy supply market and promoting solar tours, ensuring direct contact with the technologies. The sessions were very practical and informal so as to foster the debate and exchange of experience among speakers and participants as well as to ensure



full understanding of the solar urban planning potentialities. One aspect to improve if this action were to be repeated would be to also organise an exhibition of products together with the market players.

5. The mobilisation of citizens

Background and general approach

A great many cities have committed to meeting climate change mitigation targets individually or by joining a corresponding initiative such as the Covenant of Mayors. One of the commonest targets set by these cities is local energy production from renewables. Solar technologies have the potential to play an important role in meeting those targets, generating decentralised heat and electricity within urban areas.

Find out more about target setting in the "Solar urban planning in POLIS cities" section on the POLIS website.

With the development of renewable energies and the process of decentralisation of heat and electricity production, new opportunities arise for consumers, as they can now meet part of their heat and electricity demands through local production or even benefit from a national feed-in tariff.

Not only home owners but also people living in apartment blocks can take part in renewable energy projects. In many countries, it is not yet very easy to realise these types of participatory projects, which is one reason why we focused on this type of project in the POLIS pilot actions.



Although the operation of solar thermal and solar photovoltaic plants is fairly straightforward, some issues need to be assessed, namely the possibility of installing solar thermal systems in existing multi-family buildings and connecting PV systems to the conventional power grid. This is not always easy due to legal and/or administrative constraints, a lack of investments and support, a lack of political commitment and incentives, and a lack of cultural identification and user

awareness of the possibilities and advantages associated with local energy production via solar systems.

In order to boost the role of solar energy in the urban environment, a strong communication campaign needs to be developed explaining the implementation process including the planning tools and guidelines and the interaction between the local environment and the buildings' structure. Citizens need to understand the importance of solar energy and their options for the realisation of projects.

As a start, all necessary information (about the local context for renewable energies for a single person's/joint citizens' project, the solar potential, the associated economics, the impact on urban planning and the interaction process with the buildings, etc.) needs to be made available.

Depending on the type and size of the envisaged projects, it may be necessary to approach other partners such as non-profit organisations, companies, experts and sometimes municipalities. Decisive next steps for the realisation of a jointly-owned solar installation are the search for suitable roof space and for funding.

Methodologies and tools

People can either realise a solar installation on their own roof (home owners) or establish a group that jointly owns a solar installation on a roof owned by somebody else, which is what typically happens with jointly-owned PV systems.

Solutions for installing a central field of solar thermal collectors in existing buildings are increasingly common on the market. Provided that all the condominiums agree with the project and the necessary technical conditions are in place, there are interesting solutions on the market for distributing solar hot water (or solar energy) to each apartment. Such projects can involve just the condominium – with each home owner buying a part of the system – or can be realised in cooperation with energy service companies (ESCOs), who install the solar thermal system and sell hot water services to each house.

For a jointly-owned PV system, either the roofs of public buildings (the town hall, a school, etc.) proposed by the municipality or private roofs (apartment buildings, office buildings, etc.) can be used. The organisation of a joint project can vary depending on the local legal and financial framework and may therefore require the assistance of experts. If available, feedback from similar local project experiences makes it possible to use tools, which have already proved their efficiency.

Inputs and necessary local conditions

Joint projects for solar energy installations often require the motivation and mobilisation of municipalities. In addition to motivated group members, it is important to have an internal or external group moderator. If the jointly-owned solar system is installed on a roof that is not owned by a group participant, it is essential to ensure that the roof owner is on board with the idea of exploiting their roof solar potential. Depending on the local context, different departments of the local authority and local energy partners can take part in the project and motivate the other partners to develop their own projects further.

Success factors and frequent barriers

It is important to set targets to establish medium and long-term strategies prompting the involvement of different actors, namely the citizens in the accomplishment of these goals. The national incentives and legal constraints/opportunities should be considered carefully as they tend to change periodically and it is important not to let them dominate the target definition.

Real-life cases and successfully implemented examples can play a significant role in the motivation of all actors.

Constant changes in building regulations, incentives and the framework (solar energy market) are external risks for all activities encouraging citizens to implement solar projects.

Depending on the national/local context, the legal framework, financial and logistical aspects of a jointly-owned solar energy system for a citizen solar energy investment on a roof that does not belong to one of the group members can be rather difficult.

Since the first local jointly-owned solar energy projects are often experimental, the necessary time resources for such a complex and broad planning process should not be underestimated.

Main drivers and stakeholders

The main driver for the successful implementation of a solar project owned by citizens is the informing and motivation of all project participants (citizens, experts assisting the citizens, roof owner, municipality, etc.). The compilation of best practice planning instruments and procedures, and the assessment of planning processes and options for improvement lead to increased commitment by stakeholders within the municipality. Due to the participative process, the awareness of solar energy and its contribution to sustainable development grows and, in all likelihood, also leads to further opportunities within urban planning.

It can be very helpful to involve an expert who either plays an internal or external role in the citizen project group to address legal, financial and logistical aspects of such a project.

A solar potential analysis like the ones produced during the POLIS pilot actions and a real potential assessment can be very important for the successful realisation of a citizen solar project.

 **Find out more about the pilot actions in the “Solar urban planning in POLIS cities” section on the POLIS website.**

A jointly-owned solar energy system allows participants to minimise the costs per person and to share the risk of the investment.

Financial aspects

Currently, many countries support solar energy installations through incentives and subsidies (reduced taxes, feed-in tariffs, etc.), and, depending on the local context, some municipalities also support private solar installations.

Financing schemes are in place in several countries, and special conditions and contracts can be negotiated with banks and credit institutions. ESCO companies are also a privileged partner, particularly when installing central solar thermal systems for hot water production. Schemes for renting roofs are also in place, with definition of the revenue rates based on the system's productivity.

An important instrument to implement a joint citizen solar project is the establishment of a cooperative. This model reflects the vision of a decentralised, fair and sustainable energy landscape with equal rights for all participating partners like no other. Local authorities can support the establishment of a cooperative with legal and administrative expertise and as a promoter of available roof space.

Main results

The establishment of targets on solar technology adoption is essential for the development of a long-term strategy that aims at boosting solar deployment. This strategy is to be implemented via a solar initiative to strengthen the relation between the solar market, investors and the public, new business models and investment in solar technologies, thus contributing to solar development in the long term.

The main outcome of the mobilisation of citizens regarding solar energy development is that it gives everyone the chance to contribute to attainment of the European targets for renewable energies and greenhouse gas emissions reduction. Furthermore, such projects provide an opportunity for all parties to acquire some expertise in this field – an aspect that should not be underestimated. The advantage of a jointly-owned project is that the costs per person can be minimised and the risk shared.

Following the first realisations, new projects can reuse tools and documents that have been tested and replicate citizens' jointly-owned solar energy systems.

The first jointly-owned solar energy projects established show that this kind of participatory project allows everyone to implement a renewable energy system. The advantage of such a project is that all involved can participate within the limits of their competencies.

Even if the first projects are often experimental in nature, they contribute to the development of future projects which makes such projects more attractive and worthwhile.

Impact on city targets for CO₂ reduction

The mobilisation of citizens in solar projects can be an important contributor to attaining European CO₂ reduction targets.

Acting as a partner in implementation of the city's objectives, citizens' participation and the appropriation of solar technologies is essential to successfully implement a solar strategy, and to ensure the economic viability of the proposed incentives that need to be acknowledged by the citizens.

POLIS experiences and lessons learned

The POLIS pilot action in **Lyon** aimed to mobilise local investments in PV systems and offer local citizens the possibility to participate in the development and production of renewable electricity. It encouraged them to identify potential sites and organise events for citizens and interested investors so as to set up the legal structure and finance the operation, and to develop a guide for the Greater Lyon area with specific recommendations for citizen investments in jointly-owned PV systems.

The pilot action showed that even under conditions, which were unfavourable for the photovoltaic sector at that time, a great many people are extremely interested in participating in the installation of solar energy systems. Particularly in rural areas where the energy system is extremely centralised, such projects offer a high degree of motivation and identification.

One experience gained was that it was very important to inform and explain the existing solar potential and to have an internal or external expert to assist the group of citizens throughout their project.



6. Optimising planning processes for solar potential in new areas

Background and general approach

A methodology on solar planning for a new development area leads the way in an essential assessment at the urban planning level, enabling the maximisation of solar potential.

Not only the amount and size of solar systems on roofs and walls of buildings but also the efficiency of the buildings themselves can be optimised by reducing the heating demands through the increased use of passive solar yields.

! Solar urban planning for a new development area provides a basis for energy-efficient architecture and enhanced comfort.

The planning process for a new area takes many years, and the work to integrate solar potential into the planning process should form part of this and continue until the buildings are complete. It is also important to inform future inhabitants and users about the characteristics and conditions of the new area. Following the first local tests in new areas and their feedback, the development of guidelines which serve as a basis for future local projects is advisable.

Solar requirements and targets for new urban areas should be defined by solar experts and agreed by the city council. This can be achieved by adapting a series of specific parameters to the use and density of the new area. Each urban structure has its specific potential for passive and active solar use, meaning that solar requirements can be set according to the building type and urban structure, respecting the variety of high-quality architectural and urban design options as well as financial aspects.

The specific active and passive solar requirements should be converted into a legally-binding master plan on which work should continue throughout the entire design and construction process. An optimised master plan can gradually be developed by comparing the modifications with the initial plan by using specific tools and instruments to assess the planning effects.

Methodologies and tools

Solar urban planning should include both passive and active solar energy components. The tools should be adapted to local conditions, namely to the climate database but also to the national legal framework.

Active solar potential:

To enhance the quality and cost efficiency of solar systems – both solar thermal and photovoltaic – the building surfaces need to be prepared for the installation of such systems.

To guarantee optimal sun exposure, a specific orientation and pitch as well as a shade-free area are necessary. Furthermore, the size of a possible surface area is relevant for determining the adequacy of a solar system. The size of a thermal system depends on users' hot water demands. Photovoltaic systems are less dependent on specific use since they are mostly connected to the grid. However, the size of the system can also be relevant for solar power generation to attain a certain building standard (e.g. nearly zero-energy building). Combined with heat pumps, photovoltaic systems can help to achieve a net zero energy or even an energy plus building.

The general requirements for solar systems, which are to be set in master plans or local plans, refer to the construction of optimised surface areas (e. g. all roofs facing to the south) and to the size of a system per unit (e. g. 1 kWp PV per building).

Passive solar potential:

Solar yields obtained via optimally orientated windows cover the heat losses of a building to a large extent. Depending on the building standard and the climate zone, passive solar gains can cover up to 50% of the heating demand. Passive solar heat therefore plays a very important role in reduction of a building's energy demands – at no charge.

A south-facing main window area and reduced north-facing windows are therefore essential for financially attractive low-energy buildings. Optimisation of high-density areas is crucial – paying specific attention to the lower levels, as minimum solar availability should be guaranteed in every apartment.

The general requirements for passive solar yields laid out in master plans or local plans refer to the proportion of the heating demands covered by passive solar yields (e.g. 25% for all new buildings).

An optimised master plan can gradually be developed by comparing the modifications to an initial plan or an "optimal building/area" (optimal orientation with no shading). A solar project can be improved step by step in this way.

Some tools for solar urban planning cannot immediately be transferred to other countries or cities, as there are no translations or options for including other existing local climate conditions.

▶▶ **Please also see Guideline 7 and the POLIS Toolbox at www.polis-solar.eu.**

Inputs and necessary local conditions

The work on solar optimisation should be integrated into the very first master plan and continually updated throughout the entire design and construction process.

Guidelines or criteria catalogues are helpful to guarantee a full evaluation of all options when developing the plan. These criteria should be designed as a check list with each item being verified while designing the new urban site. Recommendations are to be followed and their non-application justified.

Success factors and frequent barriers

The necessary background for decisions such as these is knowledge of the specific situation in the respective city and the CO₂ saving potential of passive and active solar energy use. All municipal staff involved in the planning process should therefore be trained and well informed about the options of solar urban planning.

▶▶ **Please also see Guideline 4 on training for solar urban planning**

The results of the solar assessment may lead to significant modifications of the urban planning design and the overall plan. However, even smaller changes can already boost solar potential (active and/or passive). The real estate developer should be involved in the process to guarantee that the evaluation outputs are critical requirements for implementation of the plan.

The solar availability criteria should be a compulsory requirement for every new urban plan. A document featuring information about the minimum local criteria necessary to optimise the solar potential is a tool that has often been requested during the POLIS pilot actions and could serve as a basis for consultations with the different stakeholders.

The solar availability criteria should be agreed in the urban plan's terms of reference so that promoters can respond to it from the very initial stages of development.

Marketing of the new area/buildings by promoting sustainable design with low energy costs constitutes one very important issue.

Barriers to solar urban planning of new development areas are:

- ▶ restrictions in the urban design process and the land-use plan;
- ▶ high local property prices;
- ▶ shrinking cities and low market demand;
- ▶ a lack of continuity during the different project phases;
- ▶ a lack of information and awareness of the different stakeholders;
- ▶ high density requirements;
- ▶ competition between solar and green roofs.

Other risks for solar urban planning of new development areas are:

- ▶ municipal staff not being sufficiently involved to be able to judge the quality of the proposals (internal or external competence needed);
- ▶ the city planning department not being able to apply the methodology for solar urban planning.

Main drivers and stakeholders

Involvement of the stakeholders is essential, starting from the first set of requirements by the municipality via the support of the municipal technicians to the general competences in the urban planning team.

The municipality and the planning department naturally need to be motivated and well trained about solar optimisation processes. They need to have an active dialogue mainly with the developers to guarantee an effective adaptation of the urban planning process.

Financial aspects

The work on optimising solar potential in new areas should form part of the urban conception process. Some tools that are already used by different stakeholders during the planning process can also be used as solar optimisation tools and therefore no specific investments are necessary.

In case the draft design plans are assessed for their solar qualification, additional evaluations are inevitable. The number of design assessments via tools will vary from case to case.

Depending on the capabilities of the municipal staff, requirements can be set by the municipality itself. If this is not the case, external experts are necessary to provide the relevant expertise. Should a municipality decide to set general solar targets, it is certainly more cost-efficient to train its own staff and to provide the necessary tools and instruments.

Additional costs could arise should the city offer complementary incentives (tax reductions, reduced land prices, etc.) to support the efforts made to reach certain targets.

The benefits of solar urban planning also influence financial aspects: reducing the heating and lighting demands and optimising solar energy production.

Solar financial analyses should be incorporated in to help with the final decision on the solar options for the building. This is particularly important for solar active technologies where an optimal balance between the energy output and its economic viability needs to be in place.

Main results

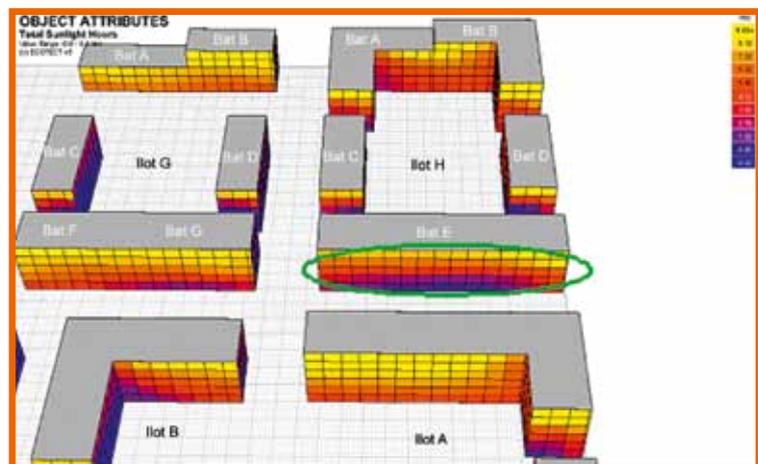
The main goal of a solar urban planning process for a new area is to facilitate the integration of solar aspects into each stage of an urban development project so that minimum levels of energy demand can be guaranteed, foreseeing the optimal use of the solar resource, both through passive techniques and active technologies.

As a result of such a concerted action, general solar targets are set for all new development areas in the city and a solar planning process considering all relevant stakeholders is designed and put in place.

An analysis of the solar potential and its optimisation for a district provides an opportunity to test the master plan proposed by the town planner in terms of its strengths and weaknesses regarding solar yields. Considering the set of opportunities to improve the solar availability of an area, namely regarding the orientation of the respective building and in relation to other buildings and urban structures, the building's architecture and the dynamics associated with its energy performance, etc., a detailed description of the considerations and effective changes evaluated and implemented in the project should be presented. This description of the optimisation process can be presented as a guide for implementing solar urban planning measures and constitutes a useful tool in mainstreaming of the methodology.

The evaluated measures and the measures effectively implemented are a balance between the technical experts and the political decision makers, who should consider the technical and economic viability of the project and define short and long-term performance targets for the area. While solar passive measures are mostly to be included in the project's initial conception stage, maximising an area's potential to receive solar active technologies does not mean that this potential has to be appropriate from stage zero, as the economics of the project also need to be balanced. The options for these should therefore allow for future installation, leaving the potential open to when it is economically feasible.

Solar planning scenarios should be presented in the initial documents of the call for tenders indicating already some possible solutions that should be considered in the plan. Innovative solutions can be achieved via design competitions, both for the urban layout and for



the buildings' architecture. This will allow for different solutions to be proposed for the same area, increasing the quality of the solutions and raising professionals' awareness of these issues.



Please also see Guideline 8 on criteria definition in calls for tender

Impact on city targets for CO₂ reduction

The annual construction rate of the building stock, e.g. in German cities, is at around 1–2%. This rate shows that new construction only has a minor impact on the energy consumption of the overall building sector. However, urban structures are long-lasting developments, as they remain in place for decades. Considering future years and related targets for CO₂ emission reduction (2030 and 2050), the new buildings will reach a share of around 20–40 % of the building stock by this time. This shows that optimised energy planning is crucial to achieve the targets set by the European Commission, the national governments and the cities.

A total of around 165 million people live in cities in the countries covered by the POLIS project. There are five billion square metres of living space and therefore around 50 million square metres of new construction every year.

POLIS experiences and lessons learned

The POLIS project revealed the importance of awareness-raising campaigns aimed at different stakeholders before and during the planning process in the respective new areas. Municipalities, planners, developers, architects, etc. need to be properly informed about solar optimisation. All stakeholders should be informed about the reasons why the solar potential of new areas should be used, which tools exist, etc. An exchange between the different stakeholders through a working group has also proved very useful in identifying the most appropriate solutions for the POLIS pilot actions.

The example of the pilot action in the district of Bron Terraillon within the Greater **Lyon** area revealed the importance of solar optimisation as an issue that should be taken into account during the entire planning process and by involving all stakeholders. This is also the reason why training, information and active exchanges should be enabled between all partners of an urban planning programme.

The results of such an exercise speak for themselves: in Bron Terraillon, about half of the buildings could be improved, leading to solar gains of between 5% and 33%. Even if the process is time-consuming when applied for the first time, it provides the basis for future work, allowing for easier application of the methodology for every new development area.

Following the POLIS findings of the Solar Action Plan for **Munich**, the development of "Urban Planning Guidelines for Munich" was decided. The guidelines – compiling instruments, recommendations and solutions from an urban planning perspective – led to enhanced commitment by the various stakeholders and, as a consequence, to the development of additional options within urban planning. The working group involving a total of nine different departments was the key to enriching the guidelines and to achieving strong commitment for its successful deployment.

7. Planning with solar optimisation tools

Background and general approach

Planning with solar optimisation tools is an opportunity to improve passive solar energy yields (lower lighting and heating/cooling demand) and active solar resources (PV and solar thermal) by improving the layout of buildings and reducing shaded areas.

Solar optimisation can be achieved by using reference guidelines, indicators and/or software tools. A variety of software tools are available on the market; some as freeware and others as purchasable software solutions. Every solar optimisation tool needs to be adapted to local conditions such as climate data, landscape morphology and, if available, also the national calculation methodology for the energy performance of buildings.

During the planning process at an area or building level, many indicators need to be taken into account and a variety of software tools can be used for simulation as well as for conception of the urban layout or building design. Some of the tools already implemented by town planners, architects, etc. could also be used to work on solar optimisation. Alternatively, special data could be entered into software for solar optimisation. Aspects of solar optimisation need to be taken into account from the very beginning of the planning phase, and different tools could be used by the different stakeholders during the whole process. It is important to choose the tools that are most appropriate for each location, project and stage of the project.

The analysis has to take into account passive solar yields both during the heating period (i.e. from October 15 until April 15) and the cooling period when restrictive solar measures need to be in place, especially in southern countries, as well as natural ventilation strategies and shadowing effects due to architectural barriers and neighbouring buildings. It is expected that the use of solar optimisation tools will allow for the construction of more energy-efficient areas and buildings, which will help improve the quality of life of future inhabitants.

Methodologies and tools

One method to optimise an urban plan for solar energy yields is to compare different solutions to an original master plan or a simulated optimal solution (no shade created by surrounding buildings, trees, etc.).

The integration of a 3D design of the reviewed area (e.g. dwg files) is important, or alternatively, the provision of possibilities to redesign the draft layout.

The first step could be to highlight the areas most affected by shade created by the neighbouring buildings. By using 3D simulations, it is possible to predict the hours of direct solar impact on the facades or the most shaded areas. Simulations can be prepared for one specific day, selected days for all seasons of the year or for a longer period.

Once these areas have been identified, all modifications on the building or on the building block level can have an impact on the solar potential and their impact could be tested by:

- ▶ shifting the buildings' sites;
- ▶ assembling buildings together;
- ▶ changing buildings' dimensions, volume and density;
- ▶ changing the orientation of roofs and buildings;
- ▶ changing the height of buildings (adding or removing floors);
- ▶ adapting the surrounding vegetation.

After applying one or more modifications, the impact on the surrounding buildings will be evaluated by indicating the loss or gain of solar energy on the facades and roofs in comparison with the original master plan.

As a next step, suitable areas for solar installations or passive solar apertures should be determined and assessed according to their size and characteristics. Disadvantageous locations due to shade or orientations should be indicated or at least quantified, as should the tested alternative design results.

All modifications on the building or building block level that improve solar gains can be synthesised in one optimised master plan.

Some computer tools for solar urban planning cannot easily be used in other countries or cities because there is no translation available and some tools do not have options for other local climate conditions. Some tools used at an international level are:

- ▶ EnergyPlus and Google SketchUp;
- ▶ Ecotect;
- ▶ Ursos;
- ▶ Solar Energy from Existing Structures (SEES);
- ▶ SOLEILI.



For more details and tools, please see the Toolbox at www.polis-solar.eu.

Inputs and necessary local conditions

Selection of the most appropriate software tool for the specific project is a challenge, as it needs to be adaptable to certain local conditions depending on the anticipated outcome. Ideally, it should include information about local climate data, building legislation, thermal regulations, etc. so as to be able to calculate the potential outcomes of the different projects.

Necessary local conditions are:

- ▶ an assessment of the initial conditions, namely solar potential assessment, energy consumption matrix, feed-in tariff, etc.;
- ▶ political commitment;
- ▶ investment capacities;
- ▶ awareness and willingness to cooperate from the local authority's side;
- ▶ effective dialogue between the different stakeholders.

Success factors and frequent barriers

Solar financial analyses should be integrated into the decision-making process. The main goal of solar urban planning is to ensure that the decisions taken today do not hinder future possibilities to use solar technologies.

The cooperation between solar urban planning consultants, urban planners, the municipality, architects and engineers can be of added value in the creation of new areas and in the requalification of existing areas.



There are very few software tools that have been specifically designed for solar optimisation at an urban level. Most of the existing tools that work at the urban level are only available with the local data of the country in which it has been created. Many of the tools identified as solar optimisation tools have other key functions (mostly architectural and urban design). Hence they have limited functions and information about solar potential.

A possible risk is the constant change and fluctuation of local legislation, incentives and the legal framework, particularly with regard to renewables (e.g. changes to feed-in tariffs in some countries).

According to the national planning and building regulations, municipalities in different countries cannot set requirements for one specific energy source within the local plans (i.e. district heating, gas or solar). This is because it would force land buyers to use a specific source of energy, which would distort the market. Nevertheless, in many cases it is possible to impose energy requirements; solar passive techniques and decentralised energy production via solar technologies play an essential role here, as they can be integrated into the built environment like no other renewable energy technology.

Main drivers and stakeholders

In order to raise awareness of solar urban planning, it is highly advisable to start implementing such practices in highly visible projects within which a change to the city's dynamics and public buildings are foreseen, taking advantage of these guidelines and the results of the optimisation process. Once an example has been set by the public authorities, private parties are called upon to respond to the challenge and to integrate these practices into their projects. The solar availability criteria should then be turned into compulsory requirements for every new urban plan.

The ability to assess the quality of the proposals is very important. This means that internal or external competences are not only necessary for urban planners, developers and architects but also for the city planning department. The ability to use the methodology for solar urban planning is fundamental for the successful implementation of solar urban planning.

Financial aspects

Computer tools for solar optimisation are available at different price levels. Some freeware tools exist, as do some software tools linked to programmes that are already used by participating stakeholders. If none of these solutions can be used for a local project, the main financial investment can be to acquire a new tool and to train staff in its use. Consideration of the solar aspects should constitute an integral component of the planning process, and the savings made by reducing energy consumption (solar passive) and energy production (solar active) should be taken into account in the overall cost estimation.



Main results

The urban planning process using solar optimisation tools aims to reduce buildings' energy demands by cutting heating and cooling needs, artificial lighting and ventilation, and increasing the potential for decentralised energy production using the buildings as the technology support matrix for active solar energy production.

The results obtained by using different tools can be 3D images outlining the amount of incident sunlight on the roof and facade of buildings, shading studies, tables indicating the percentage or kWh of solar yields, hours of sunlight per floor, estimates of energy production, etc.

The development of solar guidelines aims to facilitate a criteria-based assessment of planning documents and projects. The guidelines, requirements and necessary conditions can be implemented in solar urban planning and design, effectively embedding them in daily planning practices.

Impact on city targets for CO₂ reduction

The main goal of using solar optimisation tools is to increase the amount of sunlight received by the facades and roof of a building, defining design strategies that allow solar passive yields to be maximised during the winter, and include shading devices and ventilation strategies for the cooling period and designs for the integration of active solar technologies that allow energy to be generated all year round. By reducing energy consumption for heating, cooling and lighting, associated CO₂ emissions according to this energy consumption are also reduced. Some tools – mainly those used for PV and solar thermal production – include a calculation of the CO₂ emissions avoided.

POLIS experiences and lessons learned

During the POLIS pilot actions, research was conducted on a multitude of different solar optimisation tools. This research revealed that many software tools that are in part used by urban planners, architects, etc. can model solar optimisation (though often only to a limited extent). The main problems identified were a lack of availability in different languages, the need to include local climate data, the need to work on the urban, building block and building levels, and a lack of information about the building performance. In addition, most of these tools are complex and require prior training.

Another important issue identified during the POLIS pilot projects, is the need for information and awareness-raising campaigns for the different stakeholders, as their participation in the planning process, namely in the exchange of experiences, is essential to identify the best solutions.

8. Defining criteria for calls for tender/competitions

Background and general approach

In order to fulfil the solar requirements in urban design, solar aspects will be included in tendering and urban competitions for development areas. Only detailed information and design specifications will lead to a new planning practice, which encourages architects and urban planners to focus on energy-efficient structures and optimised solar solutions.

An agreement on general requirements and targets for the relevant area should be reached by the planning department and the respective decision-makers. It is strongly advisable to involve all key stakeholders such as local politicians and energy suppliers, interested investors and also the general public.

Detailed tender documents into which solar requirements must be integrated will be prepared by an assigned expert office and forwarded to interested architects and planners.

One of the experts involved in the jury to evaluate the designs should be a solar urban planning expert. Another option could be the participation of an external consultant advising the jury on solar aspects. The winning design should include all relevant aspects and ultimately be optimised according to solar urban prerequisites. Using existing tools to assess the quality of the chosen design can help to identify possible shortcomings. The final design should be evaluated according to the primary targets set at the start of the planning process.



Methodologies and tools

When planning urban development competitions, indicators for solar planning should be established including:

- ▶ definition of the energy demand performance targets for the new area;
- ▶ performance indicators for the public lighting systems, preference for open spaces, adequate vegetation, innovative solar designs for urban structures;
- ▶ minimum performance targets for dwellings, namely indicating minimum hours of direct sunlight, the energy demand to be met by active solar systems;
- ▶ preferred surfaces for the installation of solar systems;
- ▶ integration of the solar systems into the buildings' architecture;
- ▶ demand solutions for the installation of solar active technologies in public buildings where awareness-raising campaigns can be launched;
- ▶ lists of common errors that should be avoided, e.g. north-facing roofs, architectural barriers that cause shading on surfaces where solar systems could be affixed, south-facing entrances, wrong plant species, etc.

Inputs and necessary local conditions

The municipality should set up a dual consultancy process to assist the internal and external preparation of an urban competition for a development area:

1. External experts may assist by integrating solar criteria and targets into the specifications for the competition development.
2. An important task is to support the jury members in their assessment of solar aspects. Using specialised computer models, external experts are able to calculate passive and/or active solar losses/gains of different proposals.

Success factors and frequent barriers

It is vital that the municipality and urban agency are strongly interested and involved in the development of solar criteria and include them in tender documents. Only a concerted approach including all interest groups can lead to a successful project.

Risks of developing criteria for solar urban planning in competitions or calls for tender are:

- ▶ the municipal staff is not sufficiently involved and internal expertise is lacking;
- ▶ decision-makers and the jury are not able to assess the solar quality of the design proposals;
- ▶ agreements with all relevant stakeholders cannot be reached at the beginning of the project;
- ▶ financial or political reasons hinder the target setting process;
- ▶ opposed specifications for solar urban planning and urban design.

Main drivers and stakeholders

Main drivers for implementing criteria for solar urban planning in competitions or calls for tender are:

- ▶ the definition of concrete targets for the respective area from the outset as a guideline throughout the entire process;
- ▶ the provision of basic expertise for the drafting of council resolutions for the implementation of solar planning in new development areas;
- ▶ support for the jury members in their assessment of solar aspects of submitted projects.

The assigned external experts should be selected carefully according to their specific solar urban planning capabilities.

Financial aspects

The cost of including solar aspects in the urban planning competition is minimal when offset against the anticipated results. These are assessed according to the extended planning efforts of the internal and external staff. Assessment of the winning design with tools to evaluate the solar quality and ultimately to optimise the draft design will give rise to additional costs for external services (if not performed by municipal staff).

Main results

Good design proposals will be obtained by means of carefully developed tender documents featuring:

- ▶ concrete targets for new urban development areas/a specific development area including indicators to measure the quality of the design proposals;
- ▶ tender documents with detailed requirements and instructions for drafting solar-compatible neighbourhoods;
- ▶ a final design of the area including the compliance with solar targets; guidelines for private investors to implement solar requirements in practice.

Impact on city targets for CO₂ reduction

Not all development areas are on land owned by the local authority and not all urban design competitions are organised by the municipality. However, the development of a strategy to include solar aspects in all design competitions organised by the municipality can be seen as a strong statement and can serve as a role model for all new developments in the city, promoting the presentation of innovative and appealing solar design solutions by planners. Fostering this energy-efficient urban planning approach, the local authority will additionally exhibit highly visible expertise demonstrating its readiness for the future.

POLIS experiences and lessons learned

The solar planning scenario for a new development area in **Lyon** highlighted the weaknesses of the initial master plan. By presenting the various optimisation solutions proposed, the final document entitled "Solar planning scenario for a new development area" has been added to the call for tender documents as an example that should be followed by the candidates.

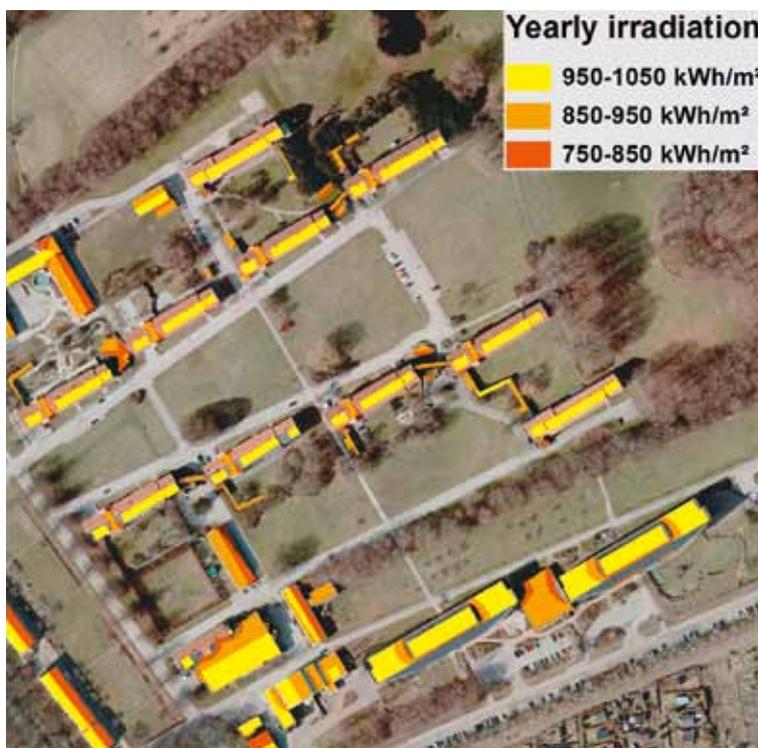
The city of **Munich** has committed to meeting ambitious climate targets. With regards to solar energy, the target is for 10% of local electricity demand to be covered by photovoltaic installations within the Munich urban area by 2015. This should be achieved through foundation of the Munich solar initiative, Solarinitiative München (SIM), in 2010. To facilitate SIM's aims through urban planning, various different planning instruments were analysed and compiled such as: detailed analyses of potentials, basic and advanced training (knowledge transfer and skill enhancement), selection of feasible surfaces, incentives for owners to install PV, analyses of possible barriers (from the urban planning point of view), identification of priority areas/suitable settlement structures, etc. All these activities helped to promote requirements for solar energy in calls for tender.



9. Introducing solar criteria into land use plans and solar ordinances

Background and general approach

The aim of urban planning is to enhance the welfare of people and their communities by creating more convenient, equitable, healthful, efficient, and attractive places for present and future generations. It is not necessary to emphasise that energy is a key topic in planning: not only the assignment of areas for certain uses but also the definition of criteria for characteristics of the future development in this area are key competences of the local authority.



A strategic plan will set the broad course for the future development of the city – by defining targets for energy production from renewables, for instance. Land use plans will then balance the needs of those living in the area with the needs of the environment. Finally, local authorities are allowed to set their own requirements within land assignment agreements when developers are building on city-owned land. Municipal land allocation means that a private stakeholder is given the right to develop a project within a certain period of time in a certain area under set conditions. This right can be granted as a land reservation or through a municipal land allocation agreement outlining the conditions and stipulations.

Considering energy efficiency criteria and renewable technology integration as part of compulsory land allocation agreements is an essential way to ensure an effective change in the local energy supply paradigm.

As national planning regulations (and consequently the competences at local level) differ throughout Europe, this guideline can only give some general recommendations. By way of example: in Spain, the solar ordinance is well known and recognised as very effective, but – due to national legislation – cannot be transferred to all countries. However, the POLIS project took a closer look at the national framework conditions in a total of nine European countries.

▶▶ Please visit the “Current practice in Europe” section on www.polis-solar.eu.

Requirements and targets for the area under consideration should be set by the relevant departments and decision-makers in the municipality together with involved stakeholders such as investors and the energy supplier(s). The requirements could be supported by and developed from targets in municipal energy and environmental strategies, policies, etc., or developed separately for the area.

Methodologies and tools

A helpful methodology to assign solar energy the right place in urban planning is to develop urban planning guidelines. In doing so, solar criteria are mainstreamed in the daily planning practice. The city of Munich established such guidelines, which include a compilation of instruments, recommendations and solutions from an urban planning perspective in the following areas:

- ▶ Development areas – competition and promotional grant
- ▶ Development areas – optimising solarisation
- ▶ Building stock – advancement of refurbishment
- ▶ Catalogue of ecological criteria – sale of publicly-owned properties
- ▶ Urban public-private agreements – land use planning
- ▶ Support programmes – subsidies and incentives
- ▶ Application of building energy-related legal framework at the local level (monitoring)
- ▶ Adaptation of local planning regulations on solar integration regarding specifications in preservation orders

Solar (thermal) ordinances

With the aim of regulating the obligation to install solar thermal systems in buildings in Barcelona, the first solar ordinance in Spain was already approved back in 1999. In 2006, it was modified to include all standards laid out in the new national building code. According to the ordinance, installation of a solar

- ▶ thermal system is mandatory in the following situations:
- ▶ if there is any domestic hot water consumption in a new building;
- ▶ in general, following the renovation of existing buildings;
- ▶ if the function of existing buildings changes.

Other such ordinances followed – some at the national (Spain, Portugal, Germany), some at the regional (Italy) and some at the local level (Ireland, Germany). Usually, the respective entity introduces building energy standards as part of planning criteria in their jurisdiction. These building energy standards require a substantial increase in the energy performance of new buildings (between 40% and 60% reduction in energy consumption) as well as a mandatory contribution of renewable energy to their thermal energy requirements.

▶▶ **Find out more about solar ordinances at www.solarordinances.eu.**

! The legal framework conditions in many countries do not (yet) allow for the establishment of a solar ordinance. Also, some cities consider such an ordinance to be counter-productive as it may lead to implementation of only the minimum necessary standards. In general, instruments and measures contributing to the motivation of stakeholders such as solar potential maps, ICT tools, advice services, tax reductions, certification of crafts enterprises, etc., are considered more helpful.

Inputs and necessary local conditions

Local authorities' determination to integrate solar criteria into land use plans, local ordinances, land allocations, etc. is crucial for the promotion of solar urban development. Ideally, targets and criteria are derived from an existing overall energy or environment strategy.

A suitable agreement stipulation, which could be used as a general example for future municipal land allocation agreements, should be developed.

Success factors and frequent barriers

The local authorities should prepare support documentation and activities that present their overall policy, strategies and incentives so as to explain and encourage acceptance of their urban planning criteria and/or ordinances.

Land allocation agreements should be standard documents that identify all the energy /environment criteria to be assessed in each plan. These documents then need to be adapted to the local conditions of the respective area. The terms of reference should be very precise so that the real estate developer can establish which points require further improvement – public spaces, building performance, most energy-efficient technologies, renewables integration, etc., for example. Such a check list is also useful to the local authority technicians to allow them to evaluate the proposals.

Other external risks are:

- ▶ a lack of regional support to encourage other municipalities to also make such a commitment, and
- ▶ a lack of defined and structured national and local support for energy efficiency and renewable technologies adoption in general.

Main drivers and stakeholders

The backing of all activities by a development strategy agreed overall by the city is crucial.

Local authorities should not only establish the framework and incentives but also be able to provide know-how and endorse competence acquisition by the promoters and facilitate the exchange of experiences among peers.

Financial aspects

Depending on the region, market conditions for development may vary substantially, which also influences the scope of action for the local authority. While in larger cities there is normally a great deal of interest in development, it can prove harder to find interested developers in rural areas, hence it is also more difficult to set high sustainability requirements there.

One important aspect in the overall field of higher energy efficiency building standards or decentralised energy production from renewables is the regional value creation. Hence the impact on job creation, import of fewer fossil energy resources (and therefore more money staying in the region), security of energy supply, etc. should be mentioned in all communications – and, wherever possible, with some concrete figures.

Main results

Since municipalities are able to set their own “rules” – be it through land use plans, planning guidelines, ordinances or requirements within municipal land allocation agreements – a mainstreamed approach is provided to set high standards for sustainable development of the city. Local leaders should be acutely aware of their function and determination to promote such approaches, as this will have a decisive influence on their range.

Impact on city targets for CO₂ reduction

Successful integration of solar and other renewable energy requirements into land use plans and land assignment will contribute to the CO₂ emissions reduction targets set by the municipality. Sustainable developments on municipal land can also inspire other stakeholders to also make efforts on privately-owned land.

The city of **Munich** estimated the potential for CO₂ emissions reduction through photovoltaics at two million tons in 20 years or 100,000 tons of CO₂ avoided per year.

POLIS experiences and lessons learned

The following recommendations stem from the experiences with solar thermal ordinances in **Spain**:

- ▶ It is very important to have a mandatory maintenance programme to confirm that the solar panels installed are working properly;
- ▶ The solar ordinance should be updated in order to consider the technical advances in the solar energy industry and the national legislation to be applied;
- ▶ The solar ordinance should not only incorporate in solar active systems (PV and solar thermal) but also passive solar systems;
- ▶ The ordinance must be specifically developed for the municipality where it is going to be applied. Sometimes it is almost literally copied from one municipality to another without the particular conditions such as climate data, urban morphology, historical protection, etc. being taken into account;
- ▶ Municipalities should have technicians capable of checking adherence to the ordinance. These technicians should be available for the citizens to consult in case of any doubts regarding the ordinance;
- ▶ Fines should be clearly established in the event that the ordinance is not adhered to.

10. Introducing solar criteria into purchase contracts

Background and general approach

Cities play a crucial role in land transactions (own land, purchase options, cooperation with developers, etc.). When selling land, local authorities have the chance to include targets which are oriented to common welfare and political consensus, and go beyond existing legal stipulations. Energy efficiency criteria and the integration of renewable technologies should therefore constitute an integral component of the contracts to ensure an effective change in the local energy supply paradigm. Experience has shown that for a variety of reasons, property developers accept such targets formulated by the local authority.

Requirements and targets for the respective area should be set by the relevant departments and decision-makers in the municipality in dialogue with involved stakeholders such as investors and energy supplier(s). The requirements could be supported by and developed from targets in municipal energy and environmental strategies, policies etc., or developed separately for the area.

Methodologies and tools

Purchasing contracts could usually include demands on orientation and the design of buildings, or requirements regarding maximum energy demand within buildings in accordance with municipal policies. The agreements could also promote certain energy solutions and set requirements for renewable energy. The concrete design of the contract will very much depend on the national regulations. In some countries, for example, legislation may not allow the requirement of one specific energy source.

As the discussions among POLIS partners revealed, one general stipulation that could be used in any purchase contract is the following:

“In the upcoming development and energy planning, the company should comment on and investigate the conditions to produce/use renewable energy within the property itself. The company should outline in writing the conditions and positions that have been expressed within the property regarding renewable energy. The investigation should be submitted to the local authorities at the latest within three months of the day of entering into this agreement.”

The following (easy yet comprehensible) wording is taken from a purchase contract that was signed in Malmö: “The developer should act for a cost and energy-efficient energy system in the area.”

Another model for reducing energy demand and promoting locally produced renewable energy has been developed and used in some municipalities: they reduce or refund the fee for the building permits for houses built to low energy or passive house standards.

Inputs and necessary local conditions

Local authorities' determination to settle the compulsory terms in purchase contracts are crucial. They need the appropriate competences and capacities to provide the technical support to public and private entities, which must comply with the criteria. Additional incentives like financial support or advice will also contribute to a higher acceptance.

The development of a suitable agreement stipulation, which can be used as a general example for future purchase agreements, supports easy implementation in daily work.

Follow-up on the energy performance of the new development after establishment is essential to evaluate achievement of the agreed targets. Sanctions – in the event that the agreement is not fulfilled – should be set in advance and applied accordingly.

Success factors and frequent barriers

The local authority should prepare support documentation and activities that provide incentives for private real estate promoters to comply with the energy requirements for the new area.

Purchase contracts should be standard documents that identify all the energy and environment criteria to be assessed in each plan. These documents then need to be adapted to the local conditions of the respective area.

The involvement of neighbouring municipalities in the project is also preferable. With many municipalities agreeing on a certain concept, it will be easier to convince developers and other stakeholders to work in the same direction.

The city council can regulate agreements regarding municipality-owned land, but a great deal of development takes place on private properties. Hence the involvement of private stakeholders in the process is also preferable. Private stakeholders could be involved and encouraged to start working with sustainable development on a voluntary basis through seminars and information campaigns. A private-public partnership in the planning phase could also help to meet the needs of the future partners and inhabitants of the municipalities. The stakeholders can offer another perspective and point of view.

On the national level, unstable financing systems for solar energy investments can be a risk. Economic instability can also affect the interest in solar energy investments and consequently also solar urban planning.

Unstable or inexplicit legal framework conditions may lead to local administrations relying on legally safe specifications and avoiding more innovative approaches.

! If it becomes difficult to regulate the possibilities for solar energy within the land allocation agreement, then it is crucial to ensure that the local plan does not hinder solar (or other renewable) energy installations.

With regard to the possibility of implementing solar urban planning concepts in municipalities, there are vast differences between municipalities within the region. For larger cities, there is normally a great deal of interest in development, while in rural areas it can prove more difficult to find interested developers. In rural areas, it can consequently also be harder to set high sustainability requirements, e.g. in purchase agreements.

Main drivers and stakeholders

The most important driver is the existence of an overall energy/environmental/sustainable development strategy, which underpins the targets and requirements to be included in the contract.

As an alternative to regulating different aspects by means of contracts, the "Constructor Dialogue Process" has been successfully used in Malmö when developing larger areas. Constructors, utility companies,

municipalities and other relevant stakeholders hold a series of meetings during which the sustainability aims for the area are set, and environmental issues not regulated in agreements are discussed.

By involving all relevant stakeholders in the process of planning and setting standards for a new development area, the compiled knowledge and experience of the local authorities and utilities, and create the best conditions for the successful integration of energy and environmental aspects into the new development.

Financial aspects

Many countries support solar energy installations through subsidies such as feed-in tariffs or investment subsidies, making the installation feasible or even profitable. When an unrestricted national subsidy is available, the local authorities could easily incentivise a solar installation requirement in contracts and agreements, having both financial and sustainability-based grounds. When subsidies are not available or only to a limited sum, solar installations may result in a considerable increase in investment costs for the new development. In this case, other renewable energy sources or energy-saving constructions might be more feasible. Solar energy demands in the contracts would then need to be incentivised by municipal energy and environmental strategies, policies, etc.

Nevertheless, specific demands on orientation and design of the buildings can still be regulated in a contract, to facilitate future installations of solar energy, in case of the introduction of a subsidy system or reduced investment costs for solar installations.

The local authority should also assess whether it would be prepared to meet the developer half way – by reducing the price of the land if the developer complies with a set of requirements, or by applying together with him for a regional/national support programme, for example.

For the economic feasibility of many projects, it would be reasonable to consider neighbourhoods (joint use of storage systems, load balance, etc.), but this is currently still very difficult due to national regulations.

Main results

Apart from the concrete requirements being implemented in the respective area, a “culture of solar planning” is being created with every new contract signed, establishing solar urban planning as a routine in the administration, but also boosting the willingness among developers to accept such requirements in the contracts.

Impact on city targets for CO₂ reduction

The successful integration of solar and other renewable energy requirements into purchase agreements will contribute to achievement of the respective CO₂ emissions reduction targets established by the municipality. Sustainable developments on municipal land can also inspire other stakeholders to make efforts on privately-owned land.

POLIS experiences and lessons learned

Most of the proposals for stipulations in purchase agreements (see “Methodologies and tools”) originate from the **Malmö** working group, which has accompanied and developed a full range of such contracts and municipal land allocation agreements.

The city of **Munich** agreed on a catalogue of ecological criteria in 2012, which also covers the field of solar technologies. As a rule for enforcement of the catalogue, a two-hour energy consultation in Munich’s Construction Centre (“Bauzentrum”) is mandatory. The minutes of this consultation are sent to the department responsible for issuing the building permits.



Large-scale solar heating at Ackermannbogen / Munich

Where to find more information

www.polis-solar.eu

The various outcomes of the POLIS project are recommended as further reading. They provide further detailed information about the partner cities' experiences and achievements

Solar urban planning manual

A compilation of best practices and successful projects and ideas implemented in the participating countries. The cases are presented in areas of targets definition, legal framework and policies, mobilisation of the solar potential and active implementation of urban planning measures involving the relevant stakeholders throughout the whole process.

The Solar Urban Planning Manual is available in English, French, German, Portuguese, Spanish and Swedish.

Conditions and strategies in POLIS cities

An overview of the current conditions in the POLIS partner cities in terms of urban and building structures, energy supply and consumption as well as existing actions and practices regarding solar energy.

Long-term solar targets of POLIS cities

An overview of POLIS cities targets related to CO₂ emissions reduction and the promotion of renewables with particular emphasis on those specifically related to solar energy (passive and active).

Action plans of POLIS cities

A report outlining the solar action plans of POLIS developed by local working groups composed by the local authorities and technical partners of the project based on information about the existing local background.

Fact sheets on pilot actions

Within the solar action plans developed by POLIS cities, more than 60 short-term measures have been identified to support the upgrade of solar energy at urban level. Of these, some measures have been identified as priority "Pilot Actions" and were implemented during the POLIS project.

Summary of the pilot actions – process and results

Development and realisation of the pilot actions was a central component of the POLIS project, and a total of 19 pilot actions were reported by the six cities. This compilation of POLIS cities' pilot actions can be used to create knowledge regarding possible use of solar energy for cities, regions and countries respectively as well as input for target setting for planners and politicians.

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