Task 63

Planning for Enhanced Solar Access and Utilization in Neighborhoods

***IEA SHC Task 63: Solar Neighborhood Planning* completes the work after more than four years, working on solar strategies, planning aspects, business models, stakeholder and citizen engagement, solar planning tools, including examples of real case studies from the 10 participating countries. This article highlights the main topics and some of the results.**

The ongoing climate and energy crisis is pushing cities to develop strategies for achieving zero/plus-energy or carbon-neutral neighborhoods. In the pursuit of sustainable urban development, integrating solar energy emerges as a key activity, offering both challenges and opportunities for cities. Some cities are front-runners, establishing exemplary showcases of sustainable urban areas by deploying passive and active solar strategies and integrating solar systems.

The urban fabric needs to utilize passive solar gains and daylight to reduce energy consumption in buildings and improve indoor and outdoor comfort for inhabitants. In addition, active solar energy systems integrated in the urban context contribute to the production of renewable energy in the form of heat and electricity. All these solar strategies support cities and citizens in achieving sustainable and healthy developments. Since the built environment has a long lifetime, we must ensure long-term solar access for buildings and outdoor environments when developing neighborhoods and cities.

From September 2019 to April 2024, a multi-disciplinary and international team worked together in SHC Task 63 with the main objective of supporting key players to achieve solar neighborhoods that facilitate long-term solar access for energy production and for daylighting buildings and outdoor environments – resulting in sustainable and healthy environments. Based on this work, processes, methods, and good examples were highlighted and developed to facilitate the successful implementation of solar strategies in neighborhoods. Below are examples of results from the Task.

Strategies for the Design of New and Existing Solar Neighborhoods

It is important to address the potential energy performance and solar availability already in the urban planning and urban design phases. Several analysis methods, including modeling and simulation, can be employed to understand a neighborhood's energy performance and assess the feasibility of implementing solar strategies and concepts. These methods may vary according to the type

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Solar neighborhoods have the potential to create environments that are,

- Energy (resource) self-sufficient
- Using a high share of renewables
- Resilient to energy prices
- Achieving high levels of thermal and visual comfort and improving air quality
- Supporting the creation of climate-proof cities

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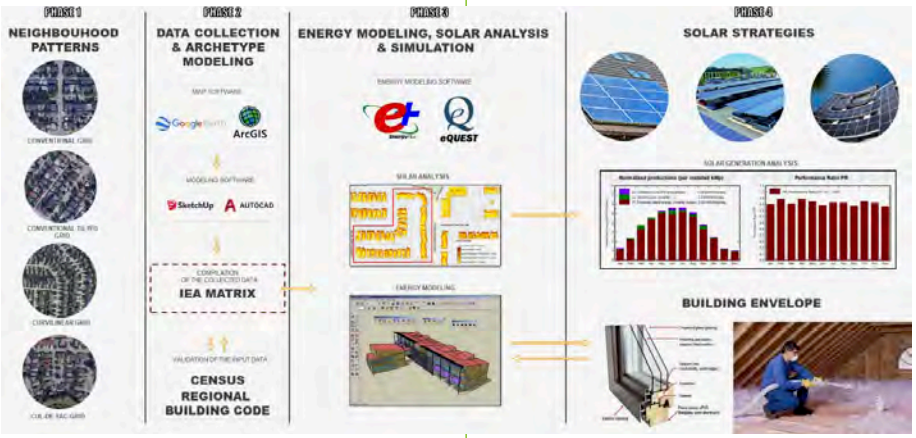

▲ **Figure 1. Overall modeling and simulation process of archetype analysis.** (Report A1, Strategies for the Design of New and Existing High Energy Performance Solar Neighborhoods)

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of neighborhoods and their phase of development, whether existing or in the planning phase. Figure 1 illustrates an example of phases employed in a specific method to analyze archetypes of neighborhoods as used in SHC Task 63. An archetype is a representative type of neighborhood. The process starts with identifying distinct neighborhood patterns, followed by data collection employing various GIS tools. Then, assuming specific construction materials, energy simulations are conducted to determine energy consumption and the potential of various solar strategies. Results show examples of analysis of the energy performance and solar strategies of existing and theoretical neighborhoods.

Read more in report A1, Strategies for the Design of New and Existing High Energy Performance Solar Neighborhoods, https://doi.org/10.18777/ieashc-task63-2024-0003.

Solar Neighborhood Decision-Making Tool

To support the early planning of neighborhoods, a tool was also developed in MS Excel. This solar neighborhood decision-making tool offers a structured approach to selecting sustainable solar strategies for neighborhood development, catering to professionals such as architects, urban planners, energy planners, and policymakers. The tool considers various passive and active solar strategies, including window placement, solar chimneys, PV systems, and solar thermal collectors, to enhance building performance and reduce energy consumption. Users can customize their selections based on specific criteria such as neighborhood type, climate conditions, and objectives and assign weights to decision criteria like ease of implementation, cost, accessibility, environmental impact, and acceptance. The tool calculates an adoption score for each strategy, summarizing its overall impact and relevance, and offers both single and composite objectives to cater to different user needs. Single objectives include daylight, passive heating or cooling, energy efficiency, electrical or thermal generation. Available composite objectives are total energy consumption, low operational cost, low/net zero carbon or net zero energy neighborhoods. The tool's output provides recommendations for suitable solar strategies based on user inputs, helping users make informed decisions towards achieving their sustainability goals. Examples demonstrate how the tool can select solar strategies for specific objectives in different climate types, providing valuable insights for sustainable neighborhood development.

Read more in report A2, Decision-Making Tool for Solar Neighborhood Planning: User Manual, https://doi.org/10.18777/ieashc-task63-2024-0004 and tool, Solar Neighborhood Decision-Making Tool, https://task63.iea-shc.org/decision-making-tool.

Opportunities for Improved Workflows in Solar Neighborhood Planning

When planning actual neighborhoods and urban areas, many parameters need to be considered. In SHC Task 63, the experts gathered data on the current state-of-the-art tools for solar neighborhoods. Examples of workflow stories were presented; a model describing a specific design and/or planning project showcasing how tools were used during this process.

The workflow stories showed exciting examples of projects and workflows where tools have played a significant role. Although the sample is low, it can be concluded that tools within the visual programming environments are extensively used in the industry and academia. At the same time, there are few examples of GIS tools that can provide the same assessment possibilities.

From the workflow stories, CAD and BIM environments seem to be the most common choice as modeling environment when designing new neighborhoods. Combined with the possibilities of a visual programming language like Grasshopper, advanced daylight and solar energy analyses have become closer to the tool workflow of architects. Another clear benefit is that, in most cases, only one model has to be constructed for multiple types of analyses. However, data handling for larger neighborhoods in those environments can still be challenging. Therefore, GIS is the common choice of tool for existing buildings and larger neighborhoods, but it might be difficult to convert the geometry to a fitting format. Also, data handling processes are more advanced. However, the field of advanced simulation is evolving quickly and will be influenced by Artificial Intelligence and Machine Learning, enabling quicker, more advanced analyses for larger neighborhoods.

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For an optimal solar neighborhood design, a district should be planned to consider not only the district itself but also how it could complement other districts or the entire city. Whereas GIS enables work at a city scale, the resolution (spatial, temporal, LOD) is usually much coarser than reached by district-scale tools. It would, therefore, be relevant to identify possibilities for working with high-definition tools.

Read more in report C1, Identification of Existing Tools and Workflows for Solar Neighborhood Planning, https://doi.org/10.18777/ieashc-task63-2022-0001.

The Role of Solar Maps

Solar maps show the potential of installing active solar energy systems on existing buildings. They are often used as a first step to acquire information about this potential. Nevertheless, the rapid expansion of these tools makes them more attractive in supporting local stakeholders such as authorities, citizens, industries, etc. The available data in these solar maps differ from map to map and country to country. Moreover, the same type of data (for example, the solar irradiance or the investment cost) can be presented in very different ways through different indicators and thresholds.

A solar cadaster, in its simplest form, can be defined as a map (usually a GIS representation) that represents how much irradiance (the incoming solar energy) is received on the buildings (mainly roofs) within a city or a specific region. For that aim, it is necessary to know at least the local typical weather conditions and building shapes and locations. SHC Task 63 experts identified and studied 56 solar cadasters from 30 countries. Where historically solar cadasters were primarily located in Europe, North America, and Australia, an increasing number of cities in Africa, Central Asia, and Central America have now also access to solar cadasters. Solar cadasters are visual tools that aim to be used by various actors, from building owners curious about their roofs' solar potential to cities investigating which buildings may have the best potential for a solar installation. For that purpose, the choice of indicators is crucial. In total, 70 metrics were referenced in the 56 solar cadasters. These metrics were classified into five categories: I) Energy, II) Technical, III) Economical, IV) Environmental, and IV) Other. More details about these indicators can be found in report C2, *Opportunities for Improved Workflows and Development Needs of Solar Planning Tools*, https://doi.org/10.18777/ieashc-task63-2024-0006.

Figure 2. Key benefits of solar mapping and stakeholder engagement. (Report C2, Opportunities for Improved Workflows and Development Needs of Solar Planning Tools)

Stakeholder engagement is vital in urban solar mapping to enable the inclusion of institutions, industry players, financiers, and consumers/prosumers for their expertise and insights (IEA, 2019). This collaborative approach facilitates accurate data collection, policy development, and conflict resolution, thereby enhancing project outcomes. Moreover, transparent communication among the actors involved in the urban planning/project process fosters the integration of solar infrastructure, informs zoning regulations, and secures community support, underpinning the project's success.

The concept of integrating solar mapping with stakeholder engagement aims to enhance solar energy technologies. By involving a diverse range of public and private stakeholders in the process, it promotes the development, implementation, and acceptance of solar solutions. The benefit of such a process can be presented as shown in Figure 2. Stakeholders can make informed decisions about where to invest in solar systems in built environments by using solar maps, which can enhance urban energy planning and optimize solar system installation. By identifying the most irradiated urban surfaces, solar maps can support and inform investors and financial institutions in assessing the viability and

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profitability of solar energy projects and systems at the building, neighborhood, and city scale. Solar maps can also serve as educational tools for the community, engaging and raising awareness about the benefits of solar energy and its feasibility. For projects requiring regulatory approval and permission, solar maps can provide necessary data and visualization to demonstrate compliance with local zoning laws and environmental regulations. This can speed up the approval process for solar systems integration into urban surfaces.

Opportunities of Using Solar Planning Tools

Solar planning tools offer significant opportunities to advance passive and active solar energy utilization. These tools enable the efficient deployment of solar systems, estimation of financial viability, daylight provision, and integration of solar energy in urban planning. However, continuous development and improvement of these tools are essential to enhance their accuracy and user-friendliness. By leveraging solar planning tools effectively, stakeholders can contribute to the growth and development of sustainable solar energy solutions.

Solar planning tools play a crucial role in optimizing solar energy utilization, promoting energy-efficient design practices, and facilitating the development of solar neighborhoods and sustainable urban environments. As the demand for solar energy and daylight access continues to grow, innovative and user-friendly solar planning tools will be essential in realizing the full potential of solar energy in our cities and communities.

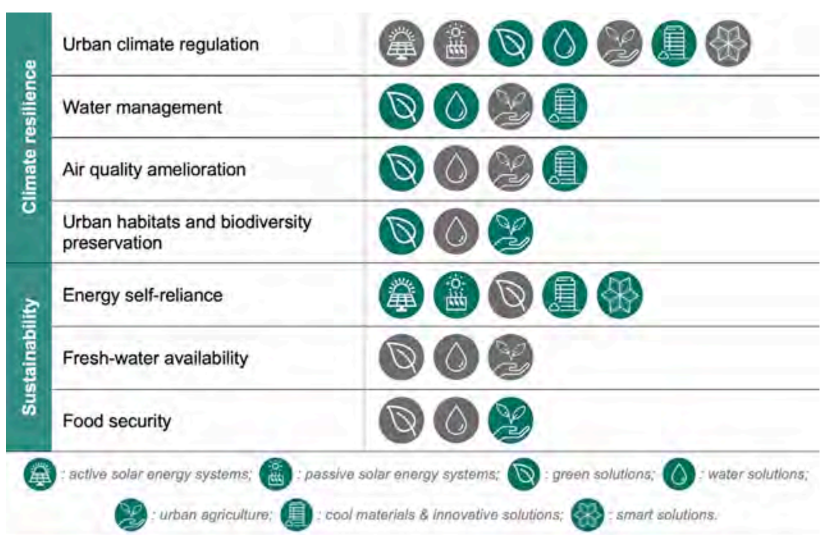
Read more in report C2, Opportunities for Improved Workflows and Development Needs of Solar Planning Tools, https://doi.org/10.18777/ieashc-task63-2024-0006.

Conscious Use of Surfaces in Neighborhoods

Urban surfaces play a major role in responding to climate change and urbanization issues. Increased utilization of all the surfaces of neighborhoods offers several opportunities not only for producing renewable energy and correctly managing passive solar gains and daylight, but also for enhancing urban sustainability and climate resilience and providing environmental, social, and economic benefits.

Within SHC Task 63, available solutions for using urban surfaces in solar neighborhoods were collected to shed light on the major role that these might play in enhancing climate resiliency and sustainability. The suitable surface uses were classified into eight major clusters (i.e., active solar energy systems, passive solar energy systems, green solutions, water solutions, urban agriculture, cool materials and innovative solutions, smart solutions, and traditional uses/materials). Furthermore, the most relevant solutions for each cluster were analyzed, and the suitability of urban surfaces to integrate these solutions was discussed, together with their contribution to the climate resilience

Table 1. Overview of the objectives each surface use cluster contributes to. Primary contribution in green, and secondary in grey



(Report B1, Surface Uses in Solar Neighborhoods).

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and sustainability objectives. The results were schematized in tables to provide an overview readily understandable by stakeholders involved in planning decisions, such as urban planners, designers, and municipalities. Table 1 shows an overview of surface uses.

For more information about the suitability of urban surfaces for the application of each usage cluster, see report B1, Surface Uses in Solar Neighborhoods, which also gives examples of different applications. In addition to this report, "Guidelines for the Design of Urban Surface Uses in Solar Neighborhoods" will be published on the SHC Task 63 website. This guide will propose a workflow for the design of neighborhood surfaces and will also refer to supporting documents and results from SHC Task 63.

Economic Strategies

Another part of our work in SHC Task 63 dealt with economic strategies. Solar neighborhood developments offer unique economic benefits; see the overview in Table 2. Since solar neighborhoods often span multiple land use spaces, local community members are key stakeholders in these developments. As such, involving the community can help promote and accelerate the investment and dissemination of these developments. In doing so, certain solar neighborhood business models can include individuals who otherwise cannot gain direct benefits from solar projects due to not having the ability to purchase their own solar equipment.

Table 2. Summary of economic benefits of solar neighborhoods

Consumers (individual)	Neighborhood/society	Developers
• No need for property ownership (renters can participate) • No rooftop space necessary • Lower risk • Opportunities for lower income consumers • No upfront costs • Save on bill costs	• Land use reappropriation • Increased energy independence • Increase property values • Landowner benefits • Job creation	• Lower operating costs • Additional technology options • Land use/solar incentives

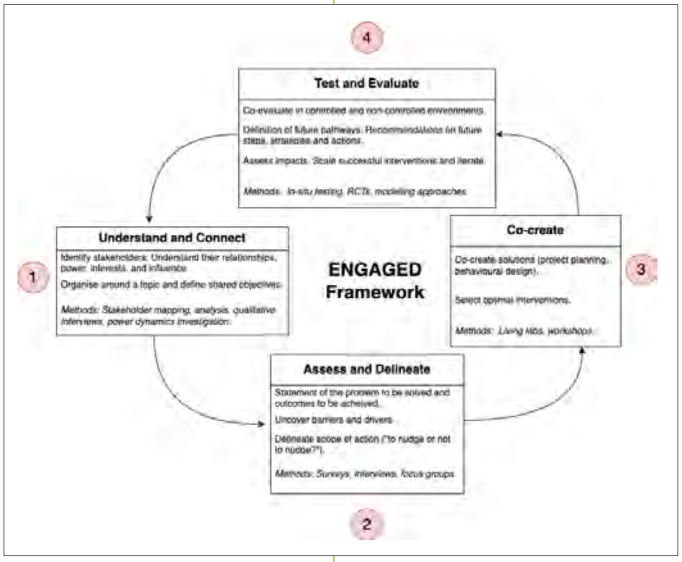
(Report B2, Solar Neighborhood Financing Mechanisms and Business Models)

The market potential for neighborhood solar is promising due to the different forms these projects can take, including the different technologies that can be utilized and the flexible size/capacity options. However, several risks exist for these developments, ranging from changes in policies that offer tax incentives for renewable energy projects to the consequences of an economic downturn that reduces the level of investment and available capital.

SHC Task 63 experts were engaged in discussions on the categorization of business model frameworks during project meetings, and the feedback was incorporated into the decision-making process for defining the design of relevant business models. Business models were developed to be flexible regarding who sponsors the project versus who ultimately owns/hosts the completed development. This allows for models where community members can be involved in some way—either as project sponsors or as part of a customer base leasing or subscribing to the project's output.

For more information, see report B2, Solar Neighborhood Financing Mechanisms and Business Models, https://doi.org/10.18777/ieashc-task63-2024-0002.

▼ **Figure 3. ENGAGED Framework Stages.** (Report B3, An Integrated Framework for Stakeholder and Citizen Engagement in Solar Neighborhoods)



Stakeholder Engagement in Solar Neighborhood Planning

An integrated framework for stakeholder engagement in solar neighborhoods was also proposed, informed by practical insights from behavioral science

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(a practice known as behavioral design). A stakeholder ENGAGEment-behavioral Design framework (ENGAGED) was developed (Figure 3). This framework is intended to inform engagement processes in solar neighborhood planning and highlight how engagement activities and citizen participation can inform several phases in the development of a solar project. A series of solar neighborhood stakeholder engagement case studies were collected from Task experts and presented. The reported activities were discussed through the lens of the ENGAGED framework, highlighting strengths and limitations. Conclusions were made, and the work formed Report B3, *An Integrated Framework for Stakeholder and Citizen Engagement in Solar Neighborhoods - ENGAGED* framework for stakeholder engagement and behavioral design. This report highlights that stakeholder engagement activities in solar neighborhoods can take many forms. In some cases, these activities are central to the planning process, while in others, their role is primarily to inform citizens and other stakeholders. By adopting a multi-stage approach, as developed in the ENGAGED framework, engagement activities can be enriched throughout the life cycle of a solar project, leading to co-created outcomes informed by a participatory process. Finally, while end-user behaviors are often considered, there are still many opportunities to integrate behavior-change considerations in a wider engagement process. Insights from behavioral science could be leveraged to promote virtuous energy behaviors that support the integration of solar technologies (as is the case in a few of the reported case studies) and increase participation in outreach events targeting citizens. Ultimately, this work aimed to bring further awareness to the importance of engaging with different stakeholder groups in the context of solar neighborhood planning and provide practical guidance in this direction.

To read more, see Report B3, An Integrated Framework for Stakeholder and Citizen Engagement in Solar Neighborhoods - ENGAGED framework for stakeholder engagement and behavioral design, https://doi.org/10.18777/ieashc-task63-2024-0001.

Case Studies Exemplify Key Aspects, Challenges, and Opportunities



▲ **Figure 4. Three case study examples from left to right Sønderhaven, Denmark; Li'ao Community, China; Eve Park, Canada**

Case studies were central to SHC Task 63, connecting many of the above topics. More than 20 case studies from 10 countries show interesting examples of neighborhoods where solar strategies, among others, have been applied. All cases were described and structured according to a common template, highlighting main features, the planning process, applied solar strategies and energy systems, surface uses, financial mechanisms, stakeholder engagement, insights from key actors, environmental, social and other impacts, tools and workflow, tools for informed design support, and finally lessons learned and recommendations. Depending on the case study, different topics were selected and described based on relevance to the case. The case studies aim to inspire and encourage others to develop solar neighborhoods. All the case studies are detailed on the Task webpage, https://task63.iea-shc.org/case-studies.

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Conclusions

The work within SHC Task 63 shows the importance of bringing in solar strategies as a central part of planning neighborhoods to make them "solar-ready." By ensuring long-term solar access for buildings and outdoor environments, the solar potential will be high. As outlined in the SHC Task 63 *Technology Position Paper*, solar neighborhoods have the potential to create environments that are:

- Energy (resource) self-sufficient
- Using a high share of RES
- Resilient to energy price fluctuations or dependence on energy imports
- Achieving and guaranteeing high levels of thermal and visual comfort, both indoors and outdoors, and improving air quality - resulting in a healthy and livable environment for citizens
- Supporting the creation of climate-proof cities.

To read the full Technology Position, visit https://task63.iea-shc.org/Data/Sites/1/publications/IEA-SHC-Task63--Technology-Position-Paper-Solar-Neighborhood-Planning-May2024.pdf.

The Task's work on strategies, methods, and tools to support such developments shows that good examples exist, and progress is definitely being made. However, despite ongoing developments, significant challenges and barriers remain. These are related to the lack of regulations on the exploitation of sunlight and access to light, sun and shade, social acceptability and/or lack of knowledge about solar strategies, competing uses of urban surfaces, drawbacks of some technologies, complex modeling of urban areas, and low profitability or failure to consider added values of solar strategies (Manni et al., 2023). On the positive side, the opportunities are many and the interest from stakeholders is growing – there is plenty of light in the tunnel!

Article contributed by Maria Wall of Lund University and Task Manager of SHC Task 63: Solar Neighborhood Planning.

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Case Study Collection: More than 20 case studies available via a map on the IEA SHC Task 63 website, https://task63.iea-shc.org/case-studies

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