SOLAR HEATING & COOLING PROGRAMME
INTERNATIONAL ENERGY AGENCY

An Integrated Framework for Stakeholder and Citizen Engagement in Solar Neighborhoods

ENGAGED framework for stakeholder engagement and behavioral design

IEA SHC TASK 63 | SOLAR NEIGHBORHOOD PLANNING

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SOLAR HEATING & COOLING PROGRAMME
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An Integrated Framework for Stakeholder and Citizen Engagement in Solar Neighborhoods

This is a report from SHC Task 63: Solar neighborhood planning and work performed in Subtask B: Economic Strategies and Stakeholder Engagement

Editors: Nicolas Caballero, Jessica Balest, Grazia Giacovelli

Authors: Nicolas Caballero, Jessica Balest, Grazia Giacovelli, Tahmineh Akbarinejad, Gilles Desthieux, Matteo Formolli, Tobias Kristiansen, Gabriele Lobaccaro, Mark Snow, Martin Thebault

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Editors/Authors

Jessica Balest

Eurac Research
Institute for Renewable Energy
Urban and Regional Energy Systems Group

Nicolas Caballero

Eurac Research
Institute for Renewable Energy
Urban and Regional Energy Systems Group

Grazia Giacovelli

Eurac Research
Institute for Renewable Energy
Urban and Regional Energy Systems Group

Reviewer

Maria Wall

Lund University
Department of Building & Environmental Technology
Division of Energy & Building Design

Contributors

Tahmineh Akbarinejad

Norwegian University of Science and Technology
Department of Civil and Environmental Engineering
Faculty of Engineering
Norway

Gilles Desthieux

University of Applied Sciences and Arts Western Switzerland (HES-SO)
HEPIA - Haute école du paysage, d'ingénierie et d'architecture, Geneva
Switzerland

Matteo Formolli

Norwegian University of Science and Technology
Department of Architecture and Technology
Faculty of Architecture and Design
Norway

Tobias Kristiansen

Multiconsult
Norway

Gabriele Lobaccaro

Norwegian University of Science and Technology
Department of Civil and Environmental Engineering
Faculty of Engineering
Norway

Mark Snow

Australian PV Institute (APVI)
Australia

Martin Thebault

Université Savoie Mont Blanc
Laboratoire procédés énergie bâtiment (LOCIE)
France

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1 Executive Summary

The present report proposes an integrated framework for stakeholder engagement in solar neighborhoods, informed by practical insights from behavioral science (a practice known as behavioral design). The report bookends a series of three workshops on these topics with Task 63 experts, as well as follow-up discussions in general task meetings where the topics of stakeholder analysis and behavioral design were discussed, and case studies collected. All these activities informed the design of our proposed framework.

We first report the state-of-the-art on stakeholder engagement methods in urban planning practice in Section 3. In Section 4 we present insights from behavioral science and detail how their application can enrich participatory processes, contextualizing these insights to the case of solar neighborhood planning. This discussion culminates in the development of a stakeholder ENGAGEment-behavioral Design framework (ENGAGED), which we detail in Section 5. The framework is intended to inform engagement processes in solar neighborhood planning and highlight how several phases in the development of a solar project can be informed by engagement activities and citizen participation. In Section 6 we report a series of solar neighborhood stakeholder engagement case studies collected from Task experts. We discuss the reported activities through the lens of our ENGAGED framework, highlighting strengths and limitations. We then present in Section 7 some overall conclusions.

Our report highlights that stakeholder engagement activities in solar neighborhoods at present can take many different 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, such as in our ENGAGED framework, engagement activities can be enriched throughout the life cycle of a solar project, leading to co-created outcomes that are informed by a participatory process. Finally, while behaviors of end-users are often considered, there is still ample opportunity to integrate behavior-change considerations in a wider engagement process. Insights from behavioral science could be leveraged not only to promote virtuous energy behaviors that support the integration of solar technologies (as is the case in a few of the reported case studies), but also to increase participation in outreach events targeting citizens. Ultimately, our goal with this report is 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.

2 Introduction

The engagement of stakeholders in urban planning projects is a crucial step in ensuring the success of urban transformations. Carrying out effective engagement actions in the context of urban planning projects can have many associated benefits, such as those listed in Table 1. Building trust, encouraging cooperation, and avoiding conflict are all important aspects to the development of a shared project's vision in view of common actions. Furthermore, the importance of engaging particularly with citizens in urban projects is becoming increasingly recognized, highlighting their role as active participants in urban transformations. The increased awareness of citizens as active participants, including the recognition and the involvement of their needs and drivers in the decision-making processes (recognitional and procedural justice respectively, Sovacool et al., 2019), has opened the door for the introduction of behavioral considerations in engagement processes, guiding the design of behavior-change interventions that can support project goals.

Table 1: Benefits of stakeholder engagement actions in urban planning.

BENEFITS OF STAKEHOLDER ENGAGEMENT ACTIONS	CONSEQUENCES IN URBAN PLANNING
Promote effective urban planning	Understanding the needs and preferences of the population and stakeholders to promote effective actions and solutions.
Avoiding conflicts with stakeholders	Avoiding opposition to the project, permitting a more effective achievement of the urban plan goal.
Shared objectives and commitment	Increasing trust and relationships among stakeholders and planners can group citizens and stakeholders together to act simultaneously and coherently. More trust in decisions, innovation, and technologies.
Increased interest and awareness	Communicating the real social, economic, and environmental benefits, the interest and commitment in the success of the project can increase.
Promoting virtuous behaviors	Using ad hoc interventions, citizens can be more likely to adopt crucially important behaviors to ensure project goals are achieved.

At the same time, engaging with stakeholders when planning and implementing projects can present challenges (Reed et al., 2018; Balest et al., 2018) such as increasing the cost of the project, extending its timeline, and being unable to reach certain specific groups (Table 2). It is important to be cognizant of these challenges and adopt strategies to best address them. Here too, insights from behavior-change research can be useful to promote increased participation, tackling the latter barrier. Ultimately, even despite these challenges, the benefits of engaging with stakeholders often outweigh their costs, and lead to the development of more successful and collaborative projects.

Table 2: Limitations of stakeholder engagement actions in urban planning.

LIMITATIONS OF STAKEHOLDER ENGAGEMENT ACTIONS	CONSEQUENCES IN URBAN PLANNING
Timeline	The urban planning may take longer engaging stakeholders.
Costs	The urban planning will require more funding and skilled human resources for engaging stakeholders.
Availability to be engaged	Some stakeholders may prefer to not be involved.

Hugely important urban transformations will take place in coming years to transform our energy system to being carbon neutral. These include crucial structural changes to energy generation, modes of mobility, and energy efficiency practices. Solar neighborhoods are an important component in this transformation. Therefore, as with other urban planning projects, stakeholder engagement and citizen participation play a key role to promote effective urban transformation.

The primary objective of the present report is to highlight instances of stakeholder engagement and citizen participation efforts in solar neighborhoods. The report suggests various insights into the components and methods that can foster participatory planning for the attainment of effective urban planning. Furthermore, it outlines the favorable outcomes that additional considerations of behavior can bring to promote deeper and more meaningful citizen participation, including through the development of community relations and dynamics, enhancing the practicality of planning and implementation actions. In this context, we explicitly consider behavioral factors, especially how practices from behavioral design can be adopted to promote behavioral change that supports the objectives of solar neighborhoods and ensures a successful participation process.

We start by briefly presenting the state-of-the art in Chapter 3, including terminology and methods associated with stakeholder engagement processes in urban planning, primarily from a sociological perspective. In Chapter 4 we introduce concepts from behavioral science, particularly behavioral economics, and discuss how practitioners can apply insights from these sciences into planning projects, which we refer to as the process of behavioral design. Chapter 5 presents a proposition for a stakeholder ENGAGEment-behavioural Design (ENGAGED) framework in urban planning projects, which considers how engagement processes in solar neighborhoods can be designed and how behavioral insights complement and enable participatory processes. Chapter 6 reports numerous examples of stakeholder engagement activities in solar neighborhood case studies, discussing their outcomes also in relation to our proposed framework. Chapter 7 discusses the report's conclusions from this work.

3 Stakeholder Engagement Methods

The Global Commission of People-Centered Clean Energy Transitions (IEA, 2021) highlights the importance of robust stakeholder engagement involving various groups such as communities, civil society, small and medium enterprises, local governments, environmental movements, and researchers, in all those projects addressing the clean energy transition. This aims to achieve successful outcomes for clean energy, by strengthening the role of stakeholders and citizens as active participants in urban transformation processes.

Stakeholder and citizen engagement involves the active participation of various types of actors (Balest et al., 2018), who can become active participants in the planning and implementation of transformation processes of cities and neighborhoods. A stakeholder is defined as any group of actors which share similar aims and who has the power or the interest to affect the outcomes of a project (Reed et al., 2009) e.g., solar neighborhood project. Stakeholders can be grouped in five helices (quintuple helix) that group actors according to their interests and actions in industry, academia, civil society, governments, environment, and un-organized public (e.g., innovators, active citizens, digital craftspeople) (Bernardi & Diamantini, 2018). Stakeholder engagement emphasizes the existence and the need to engage several perspectives, practices, values, and behaviors that all together can contribute to decisions in more innovative and place-based ways.

Stakeholder engagement is relevant to define shared objectives for solar neighborhood planning. Around a topic, such as the diffusion of solar neighborhoods for clean energy transitions, stakeholders and citizens can discuss together, share knowledge and preferences, and co-create solutions that fit with practical issues (e.g., energy poverty) and local opportunities, promoting widely effective and just transformations of cities and neighborhoods. Through stakeholder and citizen engagement, constructive dialogues and concrete actions can be addressed, gaining public support, incorporating local perspectives, and enhancing local opportunities. This can contribute to avoiding any reluctance, increasing the opportunities for just, inclusive, and effective project outcomes, and considering the peculiarities of local neighborhoods. Furthermore, stakeholder and citizen engagement can embrace innovative ideas, developing sustainable, culturally appropriate, and feasible strategies. In synthesis, an engagement process addresses the design of efficient and effective project processes and outcomes, proposing appropriate solutions. Stakeholder and citizen engagement is also important by contributing to empower, attract interest, and increase awareness of stakeholders and citizens on energy issues and opportunities, addressing the pressing demands of social transformations and climate change.

Relevant characteristics to promote an effective engagement process during its design should be considered, such as the relevance for stakeholders and citizens of the topic or project that is the object of their engagement, the concreteness and usefulness of the outcomes of the participation, the inclusion of various types of stakeholders to guarantee a reliable and representative perspective, the transparency on the project outcomes, role of stakeholders and citizens and objectives, and the selection of appropriate engagement tools and methods including digital tools. Clearly, professional capabilities and resources are fundamental to promote an effective engagement process - e.g., providing the relevant knowledge to participants - leading to effective implementation of solar neighborhoods or other related innovative transformations in cities and neighborhoods. Indeed, professional capabilities can inform and design the engagement process selecting the appropriate tools and strategies.

In fact, there are many tools and engagement techniques that have been tested and implemented in various projects. A thorough knowledge of these tools can lead to an effective choice, such as preferring living labs when promoting the co-creation of an innovative solution or considering different methods on the basis of who are the stakeholders and citizens interested in engagement. Tools and methods of engagement include interviews, surveys, and focus groups through which the participants start to express drivers, barriers, and perspectives for the transformations and the implementation of a solar

neighborhood. These tools are mainly used by researchers and other actors, who would like to define challenges and future steps in the project, starting to consult stakeholders and citizens. However, further phases for engagement ask for deeper participation in the definition of the problems to solve and the solutions to provide, transforming the role of passive individuals into active citizens (for a relevant overview see Arnstein's Ladder of Citizen Participation, Arnstein (1969)). For example, there are tools that can enlarge the participation to data creation and collection, that are mainly methods of citizen science, which can also be based on digital tools and contribute to the development of solutions. Another group of tools consist in the participatory planning, which means a process by which a community undertakes to reach a given social, environmental, or economic goal by consciously diagnosing its problems and charting a course of action to resolve those problems. In a participatory planning, several actors contribute to create the plan, sharing visions and objectives. In addition, participatory planning tools can be complemented with tools that participatively elaborate services and products. In this sense, there are several methods such as living labs, which emphasize the dialogue among various stakeholders and citizens and the co-creation processes. A living lab is a real-life environment where innovative products, services, or technologies are co-created, tested, and evaluated enabling user-centric solutions (Della Valle et al., 2021). Living labs aim to understand user needs, preferences, and behaviors to create solutions, directly engaging stakeholders and citizens, which better match their requirements. The emphasis is on real-world testing and feedback, in collaboration with the community or stakeholder groups.

To make the engagement process easier and be sure to engage all the relevant and affected stakeholders in relation to a topic (e.g., solar neighborhood planning), it is important to understand the local environment considering different perspectives (e.g., demographics, entrepreneurship, governance, policy). Among the other important elements and as a priority, stakeholders and citizens to be engaged should be identified or be given the opportunity to express their interest in being engaged in planning or other transformation processes. Stakeholder analysis is a method through which relevant information is gathered to design an effective stakeholder engagement. Stakeholder analysis consists of a mapping of all actors and citizens who are interested in the project at hand or who might influence its implementation. The initial stakeholder mapping is then enriched by collecting essential details about these stakeholders, defining their interests, and assessing their influence on project outcomes. Additionally, information about their capacity to act (agency) within an engagement process is gathered. The ability to act and intervene effectively in a participatory planning or dialogue process is also dictated by the existing relationships between stakeholders, which sometimes see an imbalance of power. In summary, stakeholder analysis typically involves the following steps: 1) mapping, 2) identification of the main characteristics of individuals (e.g., influence, interest, agency), 3) analysis of relationships and identification of power dynamics and imbalances. All information addresses the design of effective stakeholder and citizen engagement processes for solar neighborhood planning.

To promote an equal engagement of several stakeholders and citizens, it is relevant to understand the local environment, where the project intervenes. The dynamics occurring in the governance and the power imbalances may hinder the opportunities of stakeholder and citizen engagement (Gantioler et al., 2023). Power is the ability to impose one's own choice over the choice of others, directing the outcome of the project unilaterally or by a small group of actors. Imbalanced power can sometimes lead to ineffective or unjust decisions, while other times can permit to taking immediate decisions. Knowing power dynamics is important to propose and organize effective and inclusive stakeholder engagement processes, which can reinforce the support of several stakeholders and citizens to the project and its outcomes.

Understanding the local environment means proposing or engaging stakeholders and citizens in the design of effective stakeholder engagement processes, where each can contribute to different aspects during several phases of the planning process with differing levels of participation. Indeed, several participatory spaces and initiatives can be proposed to connect stakeholders, where they can share knowledge, express preferences and opinions, define solutions, co-create innovation, and co-design projects. Stakeholders and citizens may not need to be involved in every project and at every stage.

Instead, a thoughtful evaluation is essential to determine the most effective and appropriate level of engagement to achieve optimal outcomes for all parties involved, while also avoiding the unnecessary expenditure of valuable resources that stakeholders and citizens can provide. In this sense, it is important to know that there are different levels of participation. Stakeholders and citizens can engage with different levels of participation in a range from informative levels of engagement, where stakeholders and citizens exchange information around a planning project, to empowerment levels of participation, where all citizens and stakeholders involved have the same opportunities to contribute to a decision-making choice or planning decision (IAP2 2018, Balest et al., 2016).

Stakeholder engagement activities can help to better understand the social, relational, and cultural environment that addresses individual preferences, drivers, and barriers for citizen behaviors. This knowledge can help tailor specific solutions to ensure the successful achievement of shared objectives in the development of solar neighborhoods.

4 Behavioral Economics and Applications

Behavioral economic theories of human behavior can be described in opposition to the rational choice model of neoclassical economics (Mathis & Steffen, 2015). This rational choice model suggests that individuals are perfectly rational decision-makers who always aim to maximize their self-interests when evaluating decision paths, subject to costs and constraints. The rational choice agent, or Homo Economicus as it is sometimes embodied, is perfectly capable of making the necessary computations to identify and choose the optimal decision amongst many.

As valuable as this model has been for the development of economic theory, it is evidently not a descriptive model of human behavior. In stark opposition, the perspective of behavioral economics is that individuals have bounded rationality, and occasionally deviate from optimal choices (in purely economic terms) in predictable ways.

A key strand of this research focuses on the dual system theory (Kahneman, 2003). In short, this theory supports the idea that human cognition can be broadly split into two modes of thought, one quick and intuitive (System 1) and one deliberate and rational (System 2). Often, cognitive biases can be explained by the fact that decisions are guided by System 1, when they should have been addressed by System 2, leading to sub-optimal decision-making. Under this view, it becomes clear that decisions could be predictably biased by contextual factors (or "seemingly irrelevant factors"), such as how information is framed, or what is the standing social norm, as this affects our intuitive system.

The emergence of these behavioral economic theories, documented with a wide array of evidence (for an example on energy use see (Frederiks et al., 2015), have had the consequence of generating new approaches for changing behavior. The rational choice model implicitly suggests that the only successful way to shift behaviors is changing the cost-benefit structure or limiting the set of potential options altogether. This means that incentive-based mechanisms (taxation, subsidies) or regulation are seen under this model as the only viable policy tools. Under the behavioral economics lens however, shifting contextual factors can systematically address cognitive biases and promote behavioral change, which has led to the emergence of many new so-called "behaviorally informed" intervention approaches. Most notable is the large literature on "nudges". Nudges can be defined as a non-monetary, non-coercive behaviorally informed intervention that consists of changing aspects of how choices are presented to promote a specific decision.

This approach to behavior-change has proved successful in the energy domain to promote energy conservation efforts (Allcott, 2011), encourage the adoption of greener energy mixes powered by renewables (Pichert & Katsikopoulos, 2008), and to reduce peak demand (Pratt & Erickson, 2020).

Insights into new tools to encourage behavioral change have been systematized into a practice called "Behavioral Design" (ideas42, 2018). Behavioral design combines insights from behavioral science (namely behavioral economics, as well as psychology, neuroscience, and others) with impact evaluation methods to determine the causal effect of interventions. This evidence-based approach can generate new insights on the applicability of behavioral strategies in real-world contexts and, importantly, provide policymakers and practitioners with innovative behavior change tools. This is crucial, as the effectiveness of numerous policy programs often depends on the behaviors of affected stakeholders. For example, the optimal success of solar neighborhood policies often hinges on the behaviors of end-users, including in energy consumption, uptake of new technologies, building usage, participation in engagement activities, and many others. Having tools at the disposal of planners and practitioners that can promote behavioral change in the desired direction can be of crucial importance.

The "Behavioral Design Process" (ideas42, 2018) is a sequential process involving the definition of a behavioral problem, the diagnosis of its drivers, the design of solutions, and testing of these solutions.

In practical terms, the process involves first collecting data to identify a behavioral bias, assessing its drivers by referencing behavioral theories, and identifying the correct solutions to address the problem. A similar framework applied to urban planning practice is proposed in Bandsma et al. 2021. Here, the authors recommend planners wishing to adopt nudges in their urban planning designs to go through 5 phases, including: a behavioral assessment, identifying when nudging is effective, selecting the preferable nudge category and tool, and an ex-post evaluation.

Both processes highlight that planners can clearly benefit from taking a behavioral design approach. An important consideration to make is that not every problem can be addressed by a nudge, and more systemic solutions should also be considered. Moreover, in Bandsma et al. 2021 they acknowledge that the application of a behavioral design approach to planning practice is cyclical, given steps will likely be repeated once an ex-post evaluation highlights further behavioral issues that need to be considered.

While the adoption of behaviorally informed tools for the design of new policies and projects has been widely regarded as positive (especially considering that tools like nudges are often more cost-effective than traditional interventions), these tools are not without criticism. For example, nudges can often be viewed as paternalistic and limiting choice (Schmidt & Engelen, 2020). As the intention of the nudge is often not transparent, it can cause distrust when adopted into concrete policies. This is particularly worrying, as it is suggested that public trust is an important determinant in their effectiveness (Sunstein, Reisch, & Kaiser, 2018). Some of these concerns have been addressed in the literature by proposing adaptations to the nudge concept, or new tools for behavior change that prioritize agency of the decision-maker. For example, the concept of self-nudge has emerged in the literature to address concerns of autonomy and reversibility tied to nudges (Reijula & Hertwig, 2020). This approach suggests involving and instructing individuals on the applications of nudges, allowing them to become their own choice-architects and create environments that are conducive to promoting better behaviors for themselves. In a similar vein, several authors focus on “boosts” as an alternative to nudges (Hertwig & Grüne-Yanoff, 2017; Caballero & Ploner, 2022). These are interventions that prioritize agency of the decision-maker by targeting their competences, allowing them to make better decisions for themselves across domains.

It is clear from the above examples that the process of applying behavioral-insights into concrete policies and projects (which we will refer to as “behavioral design”) has evolved in recent years to emphasize the agency of the decision-maker and address common criticisms. Regardless, it is yet unclear how these insights can be practically applied in a participatory stakeholder engagement process in urban planning practice. Our ENGAGED framework aims to provide practical guidance on how planners aiming to establish a solar neighborhood can integrate insights from behavioral design into a stakeholder engagement process, highlighting a participatory approach that culminates in the co-creation of policy solutions, including nudges when appropriate.

5 ENGAGED Framework

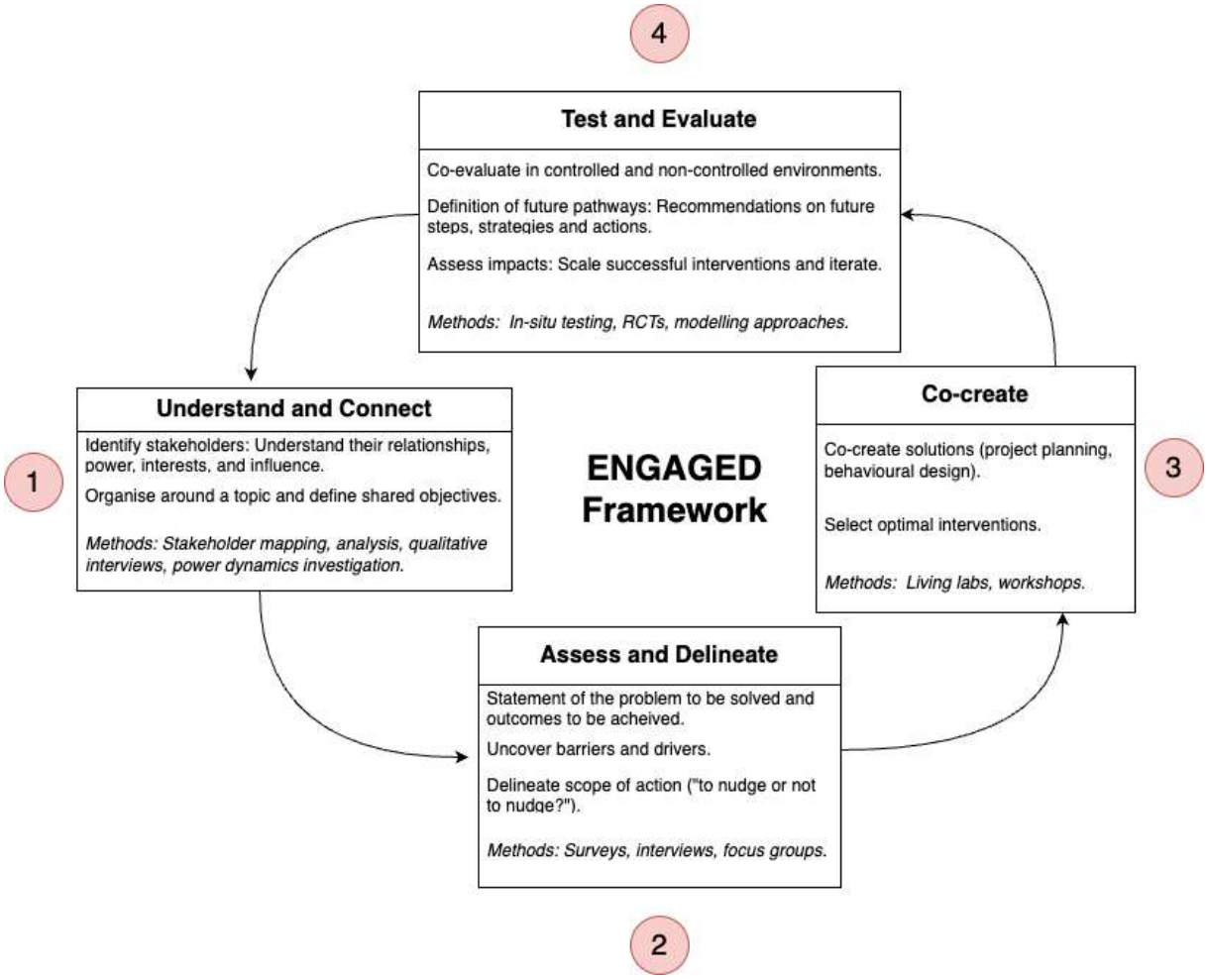

Figure 1: ENGAGED Framework Stages.

Figure 1 presents the proposed multi-stage framework for participatory urban planning that integrates insights from behavioral design into a stakeholder engagement process, which we refer to as the stakeholder ENGAGEment-behavioral Design framework (ENGAGED). The framework defines an iterative process in which the stakeholder engagement activities are intended to be carried-out in place-based contexts in which a solar neighborhood project cycle passes several phases, from planning to implementation. Behavior change considerations within the framework are primarily targeted at two types of behavior which are of key importance for solar neighborhood planning: 1) increasing the participation of stakeholders and citizens in engagement activities (workshops, meetings, surveys) and 2) promoting the uptake of virtuous energy behaviors (energy conservation, load shifting, adoption of solar technologies).

Practical steps for the application of the framework are detailed below. For each stage of engagement, we detail objectives and participatory actions, additionally offering insights with regards to how behavioral design can inform and enrich the engagement process:

- **Understand and Connect:** During this pivotal stage of the project, the primary objective will be to actively involve all interested stakeholders in the development of a solar neighborhood

project. To achieve this several participatory activities should be undertaken including carrying-out a stakeholder analysis, public consultations, fireside chats, and networking activities. The aim is to comprehensively understand the environment of actors interested in or affected by the solar neighborhoods and to connect diverse stakeholders and citizens on a shared objective.

The engagement process will be guided by the quintuple helix approach (Bernardi and Diamantini, 2018), ensuring the inclusion of diverse perspectives and representation from various stakeholder groups. This means actively engaging actors from academia, civil society, industry, governments, and the public. The involvement of unorganized public and environment-related stakeholders will also be sought, as their input can be invaluable in shaping the effectiveness of solar neighborhood planning and implementation. In this process, citizens can be actors for the creation of community ties and dynamics for effective urban transformations, promoting changes in all the aspects that can affect the solar neighborhood project implementation i.e., energy behaviors such as the choice to adopt solar plants and participatory practices e.g. to actively participate in the planning process.

Some of the questions that will be addressed in this stage are:

- Who is interested in the solar neighborhood project?
- Who can be affected by or influence the outcomes of the solar neighborhood project?
- How can a community of stakeholders and citizens be created to reinforce the effectiveness of the future implementation of the solar neighborhood project?
- What are the main objectives, needs and concerns of local actors that the project should address? How can we take advantage of coalitions between existing actors and how can we reduce inequalities due to influence and power unbalances that may undermine the project outcome (e.g., low uptake of solar installations because the needs of individual citizens were not considered)?

All these questions will begin to be addressed here, and later refined in the following stages. If instead there has already been an agreement by the different stakeholders on the project scope, other types of questions will be addressed:

- Is the project suitably set-up to address the shared objectives and the aspirations of local stakeholders and citizens?
- Have all aspects been considered?
- What is needed from different stakeholders to ensure a successful implementation?
- How can a participatory community be created to support an effective solar neighborhood project implementation, engaging stakeholders and citizens?

Identifying these necessary changes will be important to set the baseline for considering whether to adopt nudges or other behavior-change interventions in the following stages. In starting to engage citizens, behavioral science suggests adopting communication strategies that help reduce the psychological distance of residents to events that they perceive uncertain and in the future (such as climate change). This has proven effective to increase public participation at outreach events (Jones et al., 2016).

- **Assess and Delineate:** After project objectives have been defined and stakeholders identified, the following stage aims at assessing the barriers and opportunities for further development of the project. Here, methods that aim to collect place-specific information will be crucial, involving the stakeholders previously identified to tap into a diverse range of local knowledge.

  The participatory activities at this stage will focus around identifying barriers and opportunities for moving from the current status quo to a future situation that meets the defined objectives. This can mean collecting information through surveys and interviews of how current solar

technologies are being used (if any) in the neighborhood, and what factors are stakeholders concerned about with regards to the implementation of a solar project (i.e.: aesthetic considerations, distribution of value access to green energy, new business model value propositions, etc.). It is important to define the barriers and opportunities to a project's implementation. These can, for example, be behavioral barriers which require adopting behavior-change measures. Alternatively, barriers may be more structural, such as for example constraints on the use of surface areas. Therefore, it is important to define the scope of solutions that will be co-created in the following stage, including how energy behaviors can be addressed. Accordingly, one of the outcomes will be choosing whether to nudge, or not to nudge.

It is worth noting that during this stage, behavioral design considerations will also be important to promote active participation by stakeholders, particularly citizens (note that this will to some extent be relevant throughout the engagement process, as in all stages the participation of citizens will be crucial). Ensuring participation in planned engagement activities can sometimes be difficult, particularly from vulnerable groups. Numerous studies focus on how to increase participation in engagement activities using behaviorally informed approaches, or insights from marketing research (van der Linden et al., 2015). Simple and cost-effective interventions for example, such as planning prompts that encourage individuals to plan to participate to an event (Rogers et al. 2015), can have a significant impact of increasing the reach of participation activities. Framing the discussed solutions in terms of what can be achieved from immediate action, and leveraging social group norms can also be effective ways of ensuring public engagement. These examples highlight that behavioral considerations are important in the context of a solar neighborhood engagement process, not only with the aim of changing relevant energy behaviors, but also of promoting participation by different stakeholder groups (particularly citizens), ensuring a transparent decision-making process. One of the goals of this report is to highlight that policymakers and planners wishing to enact successful engagement strategies should be mindful of approaches for increasing public participation and adopt these measures to ensure the success of engagement activities.

- **Co-create:** This will be a crucial stage in the development of a solar neighborhood project. We propose that engagement should also be a key component when assessing and choosing solar neighborhood solutions. The aim of this stage will therefore be to engage relevant stakeholders identified at the start of the process in the definition of solar solutions, to achieve the shared objectives defined previously. Planners and policymakers should at this stage favor active forms of engagement that emphasize a continual and relevant dialogue between stakeholders. Living labs can play a crucial role at this stage as spaces suitable for the co-creation and testing of innovative technologies and solutions involving end-users and other stakeholder groups. Living labs can also be behaviorally informed (Della Valle et al., 2021), integrating insights from behavioral design to aid in the engagement and adoption of solutions in urban planning. Participatory activities such as workshops, constructive dialogues, citizen science initiatives and 'learning by doing' events will also be important, so long as there is a focus on active forms of engagement.

  Solutions can take different forms. They can involve co-defining technological interventions in a way that meet the needs of multiple stakeholders, which will likely be the case at the planning stage. Later in the project's life cycle, solutions will focus on defining necessary interventions to ensure a successful implementation of the project. These interventions might be technical or behavioral, based on the scope of action that was defined in the previous stages. In case behavioral interventions are suitable, our framework implies co-creating behavior-change solutions with end-users (based on the key behaviors identified in the previous stages), in a similar vein to the concept of self-nudging or boosting (discussed in Section 4). For example, interventions could focus on co-creating rules of thumb for energy use at home to develop consumption habits that match the generation of solar. Solutions could culminate in set rules

(which could for example be integrated through digital interfaces, web applications, or mobile devices) on when it is preferable to use or not use certain appliances (this can be considered an energy management boost, as detailed in Caballero & Ploner 2022). The emphasis on co-creating behavioral solutions with users (bottom-up interventions) addresses concerns of agency or paternalism which have been often leveraged against the nudging concept.

Interventions will not often be fully bottom-up or top-down, rather falling on a spectrum depending on the governance structure of the decision-making process. However, we argue that policymakers and planners adopting behavior change and technological interventions in solar neighborhoods should always engage with end-users to clarify the objectives of the intervention and, when possible, involve them in their creation.

- **Test and Evaluate:** Once solutions have been identified, the objective of this stage will be to test and evaluate them before scaling-up. This testing can take numerous forms, such as testing in a controlled (lab) environment, and testing in a "real world" environment, e.g.: using ethnographic methods, in-depth interviews, or randomized controlled trials. These approaches should be seen as complementary, not substitutes for one another (Lunn & Choisedeba, 2018).

  Actions in this stage can take a variety of forms, depending on the solutions identified through the participatory activities. If the solutions involve large-scale technical interventions, implementing them in a small-scale might be unfeasible. Evaluation will therefore need to be made on the basis of expected impacts (considering the shared objectives and status quo outlined in previous stages), and a techno-economic assessment of the proposed project. Modelling approaches will be very important in this regard. Other smaller-scale interventions, such as IT (information technology) solutions or behavioral interventions, could be tested using randomized controlled trials (RCTs). This is an important insight from behavioral design, based on a vast literature of impact evaluation of behavior-change measures.

  RCTs involve testing an intervention in the field on a relevant group of end-users and seeing how it impacts pre-defined outcomes, against a randomized control group not exposed to the intervention (Haynes et al., 2012). They are often considered the gold standard for impact evaluation of interventions and should be adopted whenever it is feasible. As context is very important for the evaluation of interventions, particularly behavioral interventions, it is advisable that interventions be tested with the final target group of end-users. This is referred to as "in-situ testing" (Soman & Hossain, 2020).

  Engaging with numerous stakeholders will be important at this stage for several reasons. Industry and business actors will be important to support the testing of different solutions. Evaluation experts will be crucial to set-up metrics for impact assessment and support the development of RCTs, and technical experts will be necessary to support techno-economic modelling approaches. Citizens will need to collaborate with experts by participating in the testing of implemented solutions (for example by actively participating in RCTs), as they will often be the final end-users/target group of interventions.

  This stage will culminate in the implementation of successful solutions for the development of solar neighborhoods which may be technical, behavioral, or social in nature. The potential impacts of the chosen solutions will be uncovered through this process. It is important that solutions are evaluated also with regards to the shared objectives set out in the first stage of the engagement process. Otherwise, the testing process will highlight potential gaps in the adopted solutions. This will lead to the reiteration of the objectives in the engagement process, leading to the circularity of our ENGAGED framework which can be applied at different phases of the project lifecycle.

6 Stakeholder Engagement in Solar Neighborhood Case Studies

In this section we report examples of stakeholder engagement activities that have been carried-out in the context of solar neighborhood projects. These activities were compiled with the help of Task experts, who provided detailed information on stakeholder engagement activities in completed and ongoing case studies. As part of IEA SHC Task 63, these and other case studies will also be published individually on the website (https://task63.iea-shc.org/) and made available for free download.

The information on stakeholder engagement activities was collected by means of a template that experts filled out (the template is reported in full in the Annex, Figure 14), and further details were elaborated during Task meetings. Here we synthesize and report expert feedback on specific case studies, following the structure below:

1. Name and description of the project.
2. Stakeholder engagement objectives and activities carried out.
3. Engagement outcomes and limitations.
4. Discussion in relation to ENGAGED framework.

The last point is a reflection on how the engagement activities carried-out within the case studies relate to our proposed framework. This is one of the crucial contributions of the present document. By highlighting how the reported activities relate to the framework we can delineate if current engagement approaches in solar neighborhoods are sufficiently behaviorally informed and to what extent they follow the ambitious iterative engagement structure proposed above. Consequently, we can outline potential limitations and considerations for future engagement activities in solar neighborhoods.

6.1 Bolzano Smart City Project (Italy)

Name and description of the project

The European project FP7 SINFONIA was a five-year initiative to deploy large-scale, integrated, and scalable energy solutions. Within this project, building refurbishment interventions to achieve high-energy performance and to improve interior comfort have been undertaken for six residential complexes in Bolzano, Italy. The complexes were existing social housing buildings, comprising a built area of 21 200 m^2. The project tested numerous innovations, which were both technological - including building energy retrofitting and the integration of RES for electricity, heating, and domestic hot water - as well as social engagement approaches. The project's engagement activities ended in 2021.

Figure 2: Bolzano SINFONIA Project. Credit: Eurac Research.

Crucially, the project carried-out its technological interventions without relocating the residents throughout the renovation works. In this way, the SINFONIA project aimed to create a suitable environment to promote the engagement of citizen/residents and change their energy behaviors. Finally, a series of in-home displays (IHDs) were installed in consenting apartments to provide real-time feedback to tenants on their levels of household energy consumption and comfort conditions of the dwelling. The displays were finally installed in 83 households throughout the project, relaying information to occupants on dwelling conditions, namely: electricity and thermal energy consumption, air quality, humidity, and temperature.

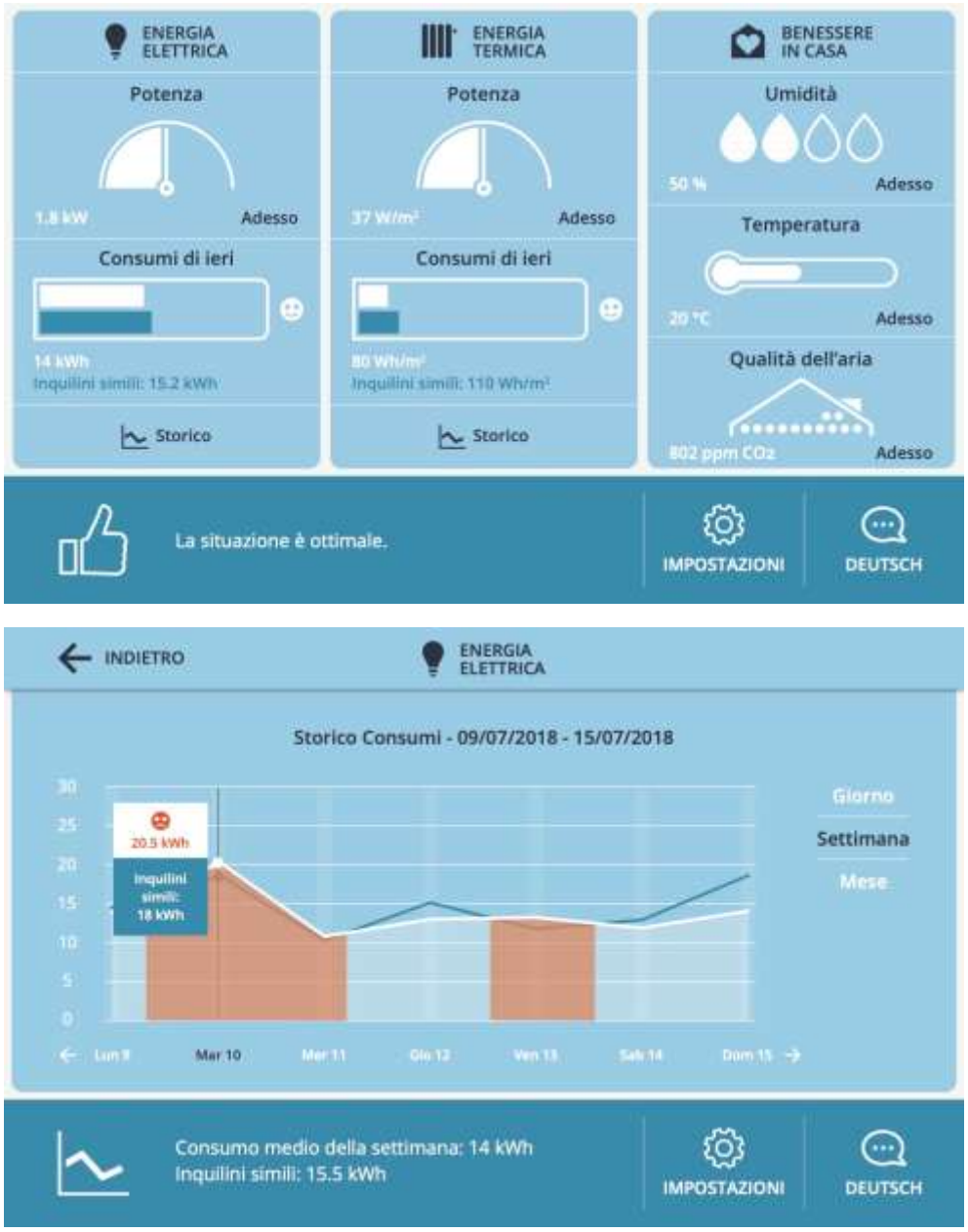

Figure 3: In-home device interfaces for houses with social comparisons. Credit: Eurac Research, Amy Segata.

Stakeholder engagement objectives and activities carried-out

The objectives of the engagement activities were to promote trust in the renovation project, ensure that citizen concerns were considered in the project's implementation, and promote energy behavior change in social housing residents to enhance energy efficiency and avoid potential rebound effects.

Figure 4: Flyer inviting residents to participate to project meetings. Credit: Eurac Research, Amy Segata.

At the beginning of the project, relevant stakeholders were identified, a stakeholder map created, and an analysis of power dynamics carried-out (material from a Task workshop reporting the power analysis for one tenant group can be found in the Annex, Figure 15). Citizen participation was an important part of the overall stakeholder engagement activities, to address the renovation project considering citizen's needs and empowering citizens in behavioral change. Several meetings and events were organized to collect feedback and ideas from residents. A survey was conducted door-to-door to 385 households, of which 277 additionally participated in interviews (Della Valle et al., 2018). These in-depth interviews were conducted on representative households with the goal of further understanding the internal dynamics within the family related to the use of energy. Particular attention was paid to the role of the household components, i.e.: who decides how to behave within the household? Additionally, self-reported socio-demographic information on residents was collected at the beginning of the project with the aim of informing the different methods of engagement (Balest & Vettorato, 2018). Furthermore, demo apartments in several condominiums were prepared and showcased during events, to show tenants the

new technologies that would be installed (new windows, ventilation system, IHDs), explain how to use them optimally, and answer any questions or concerns. Finally, towards the latter end of the activities, workshops were held with residents, allowing researchers and project leaders to better understand how tenants were using installed technologies and report any problems.

Figure 5: Demo Apartment Public Event. Credit: Eurac Research, Amy Segata.

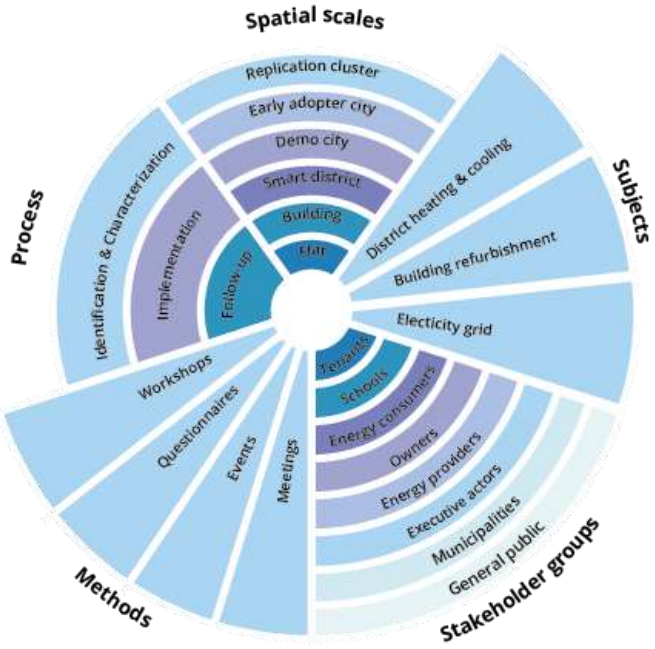

Figure 6: SINFONIA Stakeholder Engagement Toolkit. Credit: ALPS.

Moreover, to promote behavioral change, a behaviorally informed intervention was tested and integrated within IHDs of some households. This was a social comparison intervention, whereby a households' energy consumption level is displayed alongside that of a comparable group of peers, with the objective of promoting energy conservation efforts. Comparison of real-time and past-consumption data with similar tenants could be viewed at different levels of granularity by navigating through display windows and smiling/frowning faces would appear depending on whether the total level of a household's consumption compared favorably (consuming less) or unfavorably (consuming more) to the average of peers with similar household characteristics (more information can be found in Caballero & Della Valle, 2021).

Engagement outcomes and limitations

A key tangible outcome of engagement activities was in the design of the IHDs. The last meetings centered around this device. As a direct result of interaction with residents and an assessment of socio-demographic characteristics, functionalities were added to the display interface. The additions included having two language options (Italian and German), due to most of the population speaking only one of these two languages, and using large icons to accommodate reading difficulties for elderly individuals (which comprised a big portion of the resident population). Furthermore, during these meetings several prototypes were tested and validated with the residents, to ensure the final end-users participated in the display design and the features integrated. These interactions also informed the design of manuals for the IHD that were distributed at workshop activities to explain to residents the usefulness of the display (as workshops could not be carried-out in every renovated district, some of these manuals were distributed door-to-door).

The meetings also highlighted that having trusted intermediaries to communicate resident concerns to the renovation company was important to ensure trust and hence, in some districts, mediators external to the condominium were appointed. Additionally, local contractors were prioritized in the renovation works, as this was deemed important by tenants. The local agency CasaClima played a key role in the project due to the high trust of residents in this company, participating and showing the technologies installed to residents in the demo apartments.

Questionnaires also played a key role. The inclusion of social comparison interventions in IHDs was motivated in part by responses to questionnaires which highlighted the presence of cognitive biases that were exacerbated in the social housing population and could lead to inefficient energy use (Della Valle et al., 2018). The questionnaires were further used to ask residents about their needs during the project, to best accommodate them. This led to the development of some interventions such as an elevator and community satellite systems.

Several limitations were encountered in the engagement activities. The lack of participation to meetings and workshop made it difficult to engage consistently with all citizens. Unfortunately, the workshops had to be cancelled after only two were carried-out due to the onset of the COVID-19 pandemic, limiting the number of tenants that had the opportunity to participate. There were also several delays in the renovations, which made it difficult to create a strong bond of trust with residents. Due to the nature of the project, individual residents were also unable to opt-out of renovation works, which contributed to many feelings outside of the decision-making process early-on, negatively impacting trust further.

Discussion in relation to ENGAGED framework

Several aspects of the FP7 SINFONIA engagement actions can be reflected in the ENGAGED framework. Indeed, combining participatory approaches with behavioral design interventions was one of the intended aims of these activities. The renovation works had been largely defined before the start of the engagement process, so the activities were carried-out during the implementation phase of the project.

The initial steps of stakeholder mapping, power dynamics analysis and collection of socio-demographic data reflect the stage of "Understand and Connect" of our framework. Through these actions, we were

able to refine the identification of specific resident interest groups and start understanding the local context. Our first meetings can also be categorized under this step, as they aimed to connect different stakeholder groups around shared objectives concerning the renovation.

Further, the door-to-door interviews and questionnaires, as well as the following meetings that took place with building representatives, were opportunities to identify drivers for change and barriers for intervention. These steps can be categorized within the stage “Assess and Delineate”. As outlined above, several key decisions were taken because of surveys, interviews, and questionnaires. This highlights how important these methods can be to assess barriers and opportunities in the local context, and how these insights can be valuable to adjust the project to meet the needs of end-users and other stakeholder groups.

With regards to co-creating solutions, the last meetings and the two workshops played a key role. As explained, IHD interface features were co-created with tenants, and multiple prototypes were presented and iterated upon. The workshops then served as an opportunity to discuss the use of the display once it was implemented and report any issues. This reflects the “Co-create” stage of our framework.

Finally, while a thorough testing of the engagement solutions was not fully carried-out, interactions with the final IHDs were recorded, specifically how much tenants interacted with timely notifications provided by the display (these notifications informed tenants on actions they could adopt to improve monitored conditions, such as opening a window to improve air quality). Results were mixed: The average interaction between the device (notification arrival) and residents (click with notification) recorded is 1.3% (Figure 7), which matches the rates reported by the industry and social media, for example Instagram which reports between 1% and 3%. However, the social comparison interventions tested experimentally did not lead to significant energy conservation efforts, suggesting that there was limited motivation to conserve, and potentially more engagement with the IHD interface would have been necessary for tenants to meaningfully adapt their behavior.

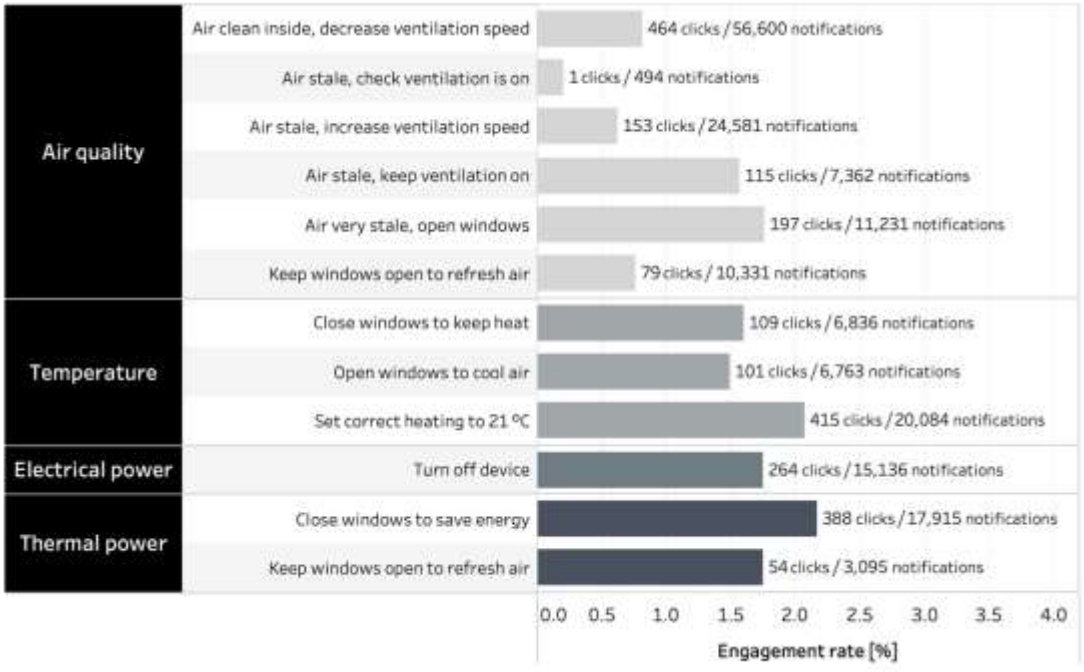

Figure 7: Average rate of interaction with different IHD notifications. Credit: Eurac Research, Aaron Estrada.

In conclusion, the engagement process in SINFONIA did successfully integrate aspects of behavioral design into its engagement strategy. Steps were clearly taken to understand tenant needs, assess the status quo, co-create solutions and some testing was performed. However, several limitations were present in our engagement efforts, which our framework can provide further guidance on.

The limited participation in project meetings could have been tackled by adopting behavioral-design techniques to increase participation, such as awareness campaigns, or leveraging trust networks of intermediaries more extensively. The fact that it was difficult to establish trust with tenants, due to many feeling like the interventions were established in a top-down fashion, highlights the importance of adopting an *iterative* engagement process such as in the ENGAGED framework. In other words, it would have been better to define project objectives, and choose at least some of the energy efficiency interventions together with tenants (beyond the IHD design). This could have led not only to more participation in engagement activities, but also more engagement with IHDs, which consequently could have contributed to the success of our behavior change approach.

6.2 Beyond White Gum Valley – the Knutsford Precinct (Australia)

Name and description of the project

The Knutsford precinct is located approximately one kilometer east of the center of Fremantle, Australia. It consists of approximately 30 ha of which 20 is re-developable vacant land. This comprises a mix of brownfield sites such as a warehouse, operating businesses, and existing residential developments.

This project tested a unique approach to community-led low carbon design and development of sustainable urban neighborhoods to deliver a range of private and public housing and community buildings. The project was part of the living laboratory project as part of the Cooperative Research Centre (CRC) on Low Carbon Living. It involved a series of participatory activities to collect feedback from multiple perspectives on how to best develop the area. In this sense, the entire research project is an exercise in participatory planning.

Figure 8: White Gum Valley. Credit: Artist's impression from LandCorp through the CRC for Low Carbon Living.

Knutsford has a unique culture. Local business and residents in the local area formed a civil society and community development group called Fremantle Arts Quarter (FreAQ).

Stakeholder engagement objectives and activities carried out

The research project objectives included, amongst others:

- Determine how much the community wanted zero carbon storage.
- Identify ways of reducing (energy) demand profiles through design and community education.

These objectives were largely targeted to promote the uptake of energy and low carbon technologies by the community in the Knutsford area.

In the early stages of the CRC engagement process, several meetings were organized where the community was invited to attend. At these meetings, reports about activities and proposals from the Knutsford area would be presented and discussed. The goal of these meetings was to give the

community information and invite them to provide input on specific issues, such as renewable energy, greening the streets, etc. These meetings informed stakeholders on the opportunities associated with redevelopment of the area and what low-carbon technologies might be deployed.

However, these first approaches were not deemed to be largely successful (Galloway & Mouritz, 2019). The community considered low-carbon technologies as a guarantee that should be delivered in any urban development and were instead much more interested in participating in a discussion on the wider goal of developing Knutsford as a world class example of sustainable urbanism.

In line with a more collaborative engagement process, a first workshop open to all people associated to the Knutsford area was held in September 2018. This workshop attracted approximately 55 people and was focused on how to renew Knutsford as it aspired to be a "world class example of sustainable urbanism". From this workshop, five projects emerged which will be discussed in the following sub-section (Galloway & Mouritz, 2019).

A second workshop was then organized to discuss new arrangements between stakeholders to deliver sustainable and resilient urbanism. This second workshop held in February 2019 was also attended by approximately 50 people, including representatives from the community, landowners, developers, academics, and city staff and councilors (Galloway & Mouritz, 2019). Two investigations were carried-out in this second workshop: "What do we need to do to go beyond business as usual?" and "What are the characteristics of an organization that would make these changes happen?".

Engagement outcomes and limitations

Of the five projects that emerged from the first workshop in 2018, two were collaborative projects between the city and the community, on which the city could immediately deliver. These included a street scaping project, and a branding and red-tape-removal project (where the city agrees to help the community develop a local identity through a branding initiative and removes any red tape that could currently hinder these activities).

The remaining three projects involved the community together with other commercial and research players (such as LandCorp, an infrastructure development company, and the CRC). These included (i) a renewable energy project that aimed to roll out innovative RES across Knutsford by connecting land owners with the appropriate companies and regulators, (ii) an engagement and planning project (community members formed a group to facilitate discussion and coordinate feedback on planning and design proposals to present to the City, LandCorp and other developers) and (iii) a project around building community cohesion (citizens formed a Civil Society group to build a community identity by organizing get-togethers, writing a city manifesto, organizing further workshops, etc.).

The investigations carried-out in the second workshop in 2019 led to a series of community responses. With regards to what should be done differently, the responses clustered around the following outcomes: meeting community needs, quality design, mixing up industrial and residential uses, the need for new financing models, and new decision-making models. With regards to how to make these changes happen, the key suggestion involved the creation of a precinct wide committee with various sub-groups and agencies deploying specific initiatives. A range of opinions on the role and power of this management group were discussed, including:

- Setting the vision for Knutsford and identifying minimum standards for developments
- Driving the process to build common infrastructure
- Determining what incentives would be available for developers to produce better outcomes.
- Identifying where the Council can bring powers to guide development
- Focusing and facilitating project-long engagement with agents and stakeholders

Discussion in relation to ENGAGED framework

Initial meetings to engage the community members can be understood as part of the "Understand and Connect" stage of our framework. These actions were considered insufficient to appropriately engage with the community. The fact that many in the community saw low-carbon solutions as a guarantee and wished instead to concentrate on a more holistic approach to sustainable urban planning shows that the engagement process can and should be re-defined based the outcomes of outreach actions during early stages. Because of these responses, experts were forced to re-think the engagement approach, leading to a more collaborative outcome.

The following workshops can be seen as attempts to "Assess and Delineate" the status quo and identify avenues for change. The second workshop especially tried to assess the status quo and collect community grievances and ideas for change. These interactions aimed to create a shared narrative on where the precinct is, and where it aimed to go. The following co-developed projects, as well as the establishment of a management committee can be seen as stages in the "Co-create" stage of our framework. Here, multiple stakeholder groups came together (including the city, landowners, members of the community), to address key development challenges and implement the shared visions discussed in workshops. No specific "Test and Evaluate" stage could be identified from current materials.

Two interesting aspects stand-out. First, the scope of the engagement in the current project is very extensive. Compared to other examples where solutions were pre-determined prior to the start of an engagement process, in the Knutsford project the explicit objective was to co-develop solutions. This seems to have aided in the participation and richness of solutions identified, with five diverse projects established. Second, specific interventions related to behavioral change were not defined. This is perhaps surprising given that energy demand reduction was one of the outcomes of the project and individual action was identified as a key barrier in achieving these goals. The project could have benefitted from considering more directly individual energy behavior-change strategies, perhaps establishing a specific project for the development and assessment of these approaches.

6.3 Finnøy Renewable Energy Project (Norway)

Name and description of the project

Finnøy island is a rural area consisting of a mix of residential buildings (approximately 500 buildings) and farm areas, covering a total of 104 km^2.

The Finnøy Renewable Energy project has the goal of developing an economically viable renewable energy system based on local resources, to reach energy and climate goals set forth by the Stavanger Municipality. The project has as the overall aim the reduction of greenhouse gas emissions, peak loads, overall energy consumption and addressing current power grid capacity issues.

Figure 9: Finnøy Island. Credits: Multiconsult.

Some of the actions carried-out throughout the project include energy assessments, implementing efficiency measures, and investigating renewable energy options in areas including solar, bio, and wind power. Moreover, one of the goals of the project is also to engage with local communities and other stakeholders involved in the decision-making process. The project is ongoing, with various stages of planning and implementation. The municipality is currently reviewing options for renewable energy installations in the area.

Stakeholder engagement objectives and activities carried-out

The involvement of stakeholders had as an objective securing the success and sustainability of the project, ensuring community support, addressing local energy needs, and identifying barriers and opportunities for the development of the area. The stakeholder groups identified included residents, farmers, property owners, energy producers, the Stavanger Municipality, and local business entities involved in the production and consumption of energy, such as the greenhouse industry which are a major stakeholder in the island.

The activities carried out involved primarily on-site interviews with local farmers, wider community meetings, and open consultation proposals. The community meetings were held in Stavanger city and attracted at least 20 participants onsite (mainly politicians representing all parties) and approximately 80 participants online. The interviews with key community members were conducted on-site with 23 people, primarily individuals involved in the farming industry as they represent the largest users of the available land and energy resources.

Task experts reported the questions that were used for interviews for the farms, including:

1. Electrical and thermal requirements at a high level.
2. Current energy supply solution.
3. Annual energy and power requirements for energy sources.
4. What is the standard facility size in your segment on Finnøy, and where do you fit into this picture?
5. What changes and investments are already planned? If there are any leading examples or ambassadors of green transformation, we would like to talk to them.
6. Can you be a sparring partner for our proposed solutions/are you interested in knowing which energy efficiency measures and local energy production can be profitable for you?

One of the outcomes of the project was estimating an electric solar energy potential of 23 GWh in Finnøy. The construction of this renewable infrastructure in the future will undoubtedly have an impact on residents. Therefore, employing engagement techniques that aim to co-create solutions will be crucial.

Engagement outcomes and limitations

Stakeholder engagement techniques played a vital role in tailoring the design of the renewable energy system, to meet the needs and preferences of local users. Behavioral aspects related to the utilization of existing buildings and energy source preferences were explicitly considered, and energy usage patterns and needs (electrical and thermal) from the biggest stakeholders on the island were assessed. The insights from stakeholder contributions were also key to fine-tune the project implementation. For example, the specific needs of the greenhouse industry members were uncovered and included in project design: They require heating when the sun is down and when solar panels output the least. Experts reported that there was not much opposition to the plans of installing more renewables on the island and noted that stakeholders were very eager on learning more about the cost, savings potential, and possibility for subsidies.

While the engagement activities were largely deemed successful, experts also reported some potential difficulties and limitations. These include the need to handle energy customer uncertainty due to the deployment of renewables, informing investment decisions, and addressing regulatory issues.

Moreover, the experts note that a wider, more diverse set of stakeholder perspectives could have been collected to ensure stronger local support.

Discussion in relation to ENGAGED framework

The stakeholder engagement activities carried out in Finnøy were largely explorative in nature, aiming to assess the status quo and needs of affected stakeholders. In this sense, these activities can roughly be categorized within the first two stages of the ENGAGED framework: Understand and Connect and Assess and Delineate. The public meetings and consultations that took place in Stavanger municipality can be considered as part of the first stage, whereas as the interviews with local farming industry members and the wider community can be categorized within the latter stage. The included interview questions highlight that some effort was also made to include interviewees in a wider decision-process by inviting them to be partners for the proposed solutions, though it is unclear if this led to future co-creation steps at this stage.

We can see many of the steps and methodologies from these stages reflected in the engagement activities in Finnøy, including the identification of stakeholders and organization around a topic (renewable installations, primarily solar), and the use of interview methods to assess barriers and opportunities for the development of renewable solutions. Behavioral aspects were explicitly considered and integrated in project design, which shows awareness from project leaders on how behavioral aspects could affect energy demand, and therefore project objectives.

The Finnøy engagement activities were successful in ensuring that stakeholder needs were considered and included in the project design. However, our framework advises further steps to ensure a more collaborative engagement. For example, citizens could be included also in the choice and design of solutions, rather than simply being recipients of information. Moreover, the consideration of behavior opens the door for an assessment of how behavioral solutions can factor into the mix of proposed solutions. For example, changing energy consumption habits of residents can promote the adoption of renewable solutions. Finally, since residents were not widely considered (as one of the reported limitations), such participation could also have been motivated with the use of behavioral interventions, as with other case studies.

6.4 Photovoltaic Systems at Møllenberg (Norway)

Name and description of the project

The Photovoltaic Systems project at Møllenberg has the goal of enhancing the exploitation of solar energy in Nordic cities through the digitalization of the built environment. Indeed, the Trondheim municipality's 2017-2030 energy and climate plan, has the ambition to become a zero-emission city through, among others, the implementation of active solar strategies on buildings' roofs as a favorable solution to upgrade the building envelope, while increasing the share of renewable energy sources, self-sufficiency, promote financial security and avoiding energy poverty.

Figure 10: Trondheim location and Møllenberg district Credit: Fontaine Romain.

Some of the actions carried-out throughout the project include (i) a literature review to identify the objectives and the energy targets of the municipality energy and climate plan and the technological solutions currently available on the market, (ii) a stakeholder analysis, and (iii) a survey campaign targeting the people living in Møllenberg to enhance the citizens' participation and engagement. The current barriers for the integration of photovoltaic systems in the such high-sensitive heritage area have been identified, as well as the future energy pathway to address them.

The Møllenberg district primarily consists of two-stories wooden houses built during the 1880s and 1890s. Due to its historical value, the area is now listed by the municipality as a heritage site, making it particularly challenging for inhabitants to obtain permissions for renovation interventions, despite the urgent need for them.

Stakeholder engagement objectives and activities carried-out

The stakeholder's engagement was necessary for this project to identify the most effective ways to foster social acceptance and understand the initial attitude toward the installation of photovoltaic systems in Møllenberg. An on-line survey with eight questions was created and administered in Microsoft Forms, targeting people living in the Møllenberg district. The survey was accessible from flyers with a QR code distributed in the mailboxes of Møllenberg.

Engagement outcomes and limitations

The results from the survey showed that most of the residents (86%) are "very positive" or "positive" towards the idea of installing solar panels on the roofs of Møllenberg. The main barriers to the installation of solar technology were identified as (i) concerns about the price, (ii) lack of knowledge, (iii) restrictions from the municipality, and (iv) inability of many tenants to decide since they were just renting the apartment and not owning it. Finally, the preferred way for people to be involved in the process of installing solar panels in the Møllenberg neighborhood resulted in the use of surveys, meetings, and visualization.

To facilitate clear visual communication among stakeholders, this project employs 3D visualization technique with 'street view' feature, integrating diverse models into a unified visual platform which let the citizens walk through their neighborhoods. The visualization combines existing SketchUp 3D models of Trondheim with solar simulations and immersive 360° imagery captured by drones. It features accurate 3D representations of proposed solar panel installations, enriched with informative data like cost, appearance, technology providers. Users can interact with various layers, smoothly transitioning between 3D model and overlaid solar simulations. This engaging and intuitive interface aims to clearly visualize the solar integration potential and its architectural harmony, promoting a comprehensive understanding and appreciation of the project's ambitions and mitigate stakeholder's concern.

Figure 11: Enhancing stakeholder engagement with a virtual neighbourhood tour showcasing solar panels, providing key information to address their concerns.

Based on these findings, the following actions are recommended:

- The Byantikvaren (the municipality office responsible for cultural heritage) should be targeted as the primary actor to increase social acceptance of photovoltaic technology in Møllenberg.
- The engagement between the public sector and people should be encouraged.
- Innovative visualization tools (i.e., augmented reality, virtual reality mixed reality) and platforms (i.e., 3D model, digital twin) should be developed. This, for instance, could make possible just by using a smartphone to visualize how a house would look after the installation of solar panels, as well as provide information about the available products, energy-saving potential, and investment costs.
- A sustainable funding model including all the stakeholders should be created to lower the economic barrier to investing in photovoltaic technology in the future.

While several actions are recommended, some limitations could emerge in future stages of the project. These include the difficulties related to get renovation permissions due to cultural heritage constraints in the area, the skepticisms towards solar availability at high latitudes, the challenges of reaching all stakeholders (i.e., public, private, people) and stimulating a constructive dialogue and feedback, and the fact that many people living in Møllenberg are students and do not correspond to the owners of the houses/apartments, hindering their ability to actively contribute to the exploitation of solar energy.

Discussion in relation to ENGAGED framework

The integration of online surveys with other activities and methods related to stakeholder engagement could provide further insights for the increase of acceptance of the project and to define sustainable and reliable pathways for the enhancement of solar energy in Møllenberg.

A structured understanding and connection of the diverse stakeholders in Møllenberg could support the creation of networks and dialogues aimed to define acceptable and reliable pathways. First, a stakeholder mapping is recommended to define all the relevant stakeholders to be engaged in the decision-making process i.e., industry, academia, civil society, governments, environment, and un-organized public (e.g., students). A living lab could be activated to create opportunities for dialogue, encompassing several challenges – e.g., the incompatibility between historical value of buildings and solar energy plants – and defining solutions. To foster participation of a diverse range of citizens in these living labs, participatory approaches informed by behavioral science could have been adopted, as low participation was cited as potential limitation of the project by the experts. These methods could have been especially targeted to the large student population living in the area (for examples framing the benefits of participation to the solar development project in environmental rather than financial terms, as many students are likely to be non-ratepayers), involving them in co-creating solutions through participatory events. As the success of any photovoltaic system is dependent also on behavioral factors, the solutions discussed could also have been behavioral in nature, such as co-creating “self-nudges” that promote shifting consumption patterns to accommodate new technologies.

The online survey was successful in defining the main actions to activate and the main limitations that might be encountered. In order to strengthen the stakeholder engagement for reliable and acceptable decision making, further steps should be taken i.e., structured stakeholder mapping, activation of living lab, etc.

6.5 ZAC Ferney-Genève Innovation (France)

Name and description of the project

The ZAC (Zone d'Aménagement Concerté) Ferney-Geneve is part of a broader initiative known as "The Innovation Circle," encompassing four districts—Plaimboeuf, la Poterie, Très la Grange, and the Cité Internationale des savoirs—in Ferney-Voltaire, France, with the ambition to evolve into significant economic hubs. The project is grounded in several objectives, including establishing a new innovation hub, integrating environmental and hydraulic elements into the site, and reinforcing biodiversity corridors. Furthermore, the initiative seeks to construct energy-efficient buildings served by a heating network powered by renewable energy sources.

Figure 12: Ferney-Voltaire. Credit: Terrinov.

To attain these multifaceted objectives, the Ferney Genève Innovation ZAC is actively pursuing various strategies. Firstly, there is a concerted effort to reduce dependence on gas as a backup in the central energy production network. This involves expanding energy supplies and exploring alternative options. Secondly, there is a commitment to augment the overall share of renewable energy sources within the network. This not only aims to sustain a reduced value-added tax (VAT) rate of 5.5% but also encourages the adoption of environmentally friendly energy practices. Lastly, the project is focused on exploring the valorization of waste heat, with the objective of enhancing the profitability of a photovoltaic network. By efficiently harnessing this excess heat, the initiative seeks to elevate the economic viability and overall efficiency of the system.

Stakeholder engagement objectives and activities carried-out

TERRINOV-SPL holds exclusive authority over various activities pertaining to both participation in planning and implementation decision-making processes, as well as the provision of services and products. Nevertheless, there are planned citizen engagement activities. These include conducting online interviews, providing display houses by Ferney Geneve to elucidate the project, engaging with other stakeholders by disseminating information about the project, and making PDF documents about the project accessible on the internet.

Engagement outcomes and limitations

Excluding actors who are not strictly governmental or economic actors from numerous planning and implementation activities has the potential to compromise the effectiveness of agreed-upon actions. This exclusion may result in situations in which the aspirations, issues and needs of other stakeholders are neglected, giving rise to conflictual situations or lack of interest in the final product.

Participation can vary depending on its level. Providing information to citizens and stakeholders can enhance awareness related to the project and its expected benefits. However, mere information is sometimes insufficient to generate active and positive dynamics within a neighborhood, which aims to establish social housing programs and competitive economic hubs.

Discussion in relation to ENGAGED framework

The ENGAGED framework can provide instruments to define in a wider way a list of stakeholders interested in this project, who can positively affect the achievement of the project. The quintuple helix extends beyond governmental and economic stakeholders, placing emphasis on other pertinent participants essential for addressing project outcomes, including civil society, academia, the environment, and the unorganized public. Considering the aspirations, issues, perspectives, and needs of this diverse range of stakeholders promotes innovation in devising solutions, services, and products, thereby mitigating societal and climate challenges such as inequalities and the imperative for climate change mitigation.

Once a broad spectrum of stakeholders is identified (Understand and Connect) to gain a more expansive perspective on the local context (Assess and Delineate), the activation of participatory tools, such as living labs (Co-create), can foster positive dynamics for co-creating innovative solutions. The Test and Evaluate phase may yield insights that bolster the competitiveness, justice, and inclusivity of the project outcomes.

6.6 *Un parc solaire de la Genève internationale* (Switzerland)

Name and description of the project

The objective of this project was to evaluate the feasibility of installing photovoltaic panels on buildings, owned by the members of 2050 Today, using techno-economic criteria, with the aim of initiating individual or group solar installation projects. The study specifically examines both individual buildings and clusters of adjacent buildings managed by the same operator.

Figure 13: 2050 Today: event and member buildings in International Geneva. Credit: 2050Today and Gilles Desthieux.

2050 Today is a climate action forum in Geneva, bringing together institutions from International Geneva, including permanent missions, international organizations, private entities, and civil society, to address climate change by significantly reducing greenhouse gas (GHG) emissions. The forum facilitates climate action by assisting members in measuring their emissions, implementing common and tailored solutions through working groups, and benefiting from applied research. It encompasses over 60 institutions from International Geneva.

Developed as a partnership involving the Swiss Confederation (Federal Department of Foreign Affairs), the Republic and Canton of Geneva, the City of Geneva, the University of Geneva, and Industrial Services of Geneva (SIG), 2050 Today is a unique initiative supported by Swiss authorities at all levels to promote the decarbonization of International Geneva. These five institutions collectively form the 2050

Today Committee of the Parties, as outlined in the Convention of Collaboration signed in June 2022. This collaboration was witnessed by the United Nations Office at Geneva, the Permanent Mission of the Republic of Rwanda, and the World Council of Churches. The University of Geneva serves as the hosting institution for 2050 Today.

Stakeholder engagement objectives and activities carried-out

The project aligns with the mission of 2050 Today, which is to enlist the commitment of the 60 member institutions of International Geneva in the pursuit of energy transition and carbon neutrality. Given the substantial electricity consumption of these institutions and the limited prevalence of solar PV installations, the project aims to stimulate solar installations on the roofs (and potentially the facades) of the buildings, thereby reducing dependence on the grid.

The initial phase involved creating an inventory of the solar production potential for each building or group of buildings and conveying key energy and economic key performance indicators (KPIs) to the respective property owners. Consequently, HEPIA conducted a feasibility analysis for each building or group of buildings, and the findings were communicated to each member. Members or their representatives, primarily building management companies, were then invited to a workshop to discuss the results and explore potential next steps. The upcoming phase will involve supporting members in initiating solar installations (once the potential is confirmed) and devising optimal strategies, including the possibility of aggregating installations into microgrids.

Engagement outcomes and limitations

The engagement process is at its first stages: Some analysis of the stakeholders and context has been conducted and a first workshop with members has been carried-out. However, the process should go further. Surely, the engagement of such an established network can be a strong foundation for an effective participatory process capable of addressing needs, expectations, and aspirations.

Discussion in relation to ENGAGED framework

The ENGAGED framework can contribute giving a cyclic perspective to the stakeholder and context analysis. After defining a first stage of the analysis, deeper understanding based on the engagement of a wider group of stakeholders and perspectives can enhance the capacity of the project to organize an engagement process for urban transformations. Since the process at this stage does not include citizen perspectives, no behavioral considerations have been reported. However, end-users of buildings will need to be considered, opening the door for participatory activities and the integration of energy behavior-change interventions. The process is still at its early stages.

7 Conclusions

The present document provides an overview of stakeholder engagement and citizen participation activities carried-out in solar neighborhoods reported in the IEA SHC Task 63 case studies. The report culminates a process of discussion and interaction with Task experts across 3 workshops centered around the topics of stakeholder analysis and behavioral design in solar neighborhoods, where a series of materials and case studies were collected.

In the first instance, this report briefly presented the theories and methods of stakeholder engagement and behavioral design, focusing on practical applications of these methods in urban planning. We then proposed the ENGAGED framework for the application of stakeholder engagement approaches in solar neighborhood planning, informed by the existing literature and discussions with experts on past project experiences. Finally, we analyzed a series of case studies where engagement activities were carried-out in solar neighborhood projects through the lens of participatory and behavioral design approaches. Specifically, we discussed how the stakeholder engagement and citizen participation activities reported are reflected in the different stages of our ENGAGED framework. In so doing, we highlighted the strengths of these approaches, and outlined potential directions for improvement. Overall, our aim has been to underscore the importance of stakeholder engagement and citizen participation in solar neighborhoods, with the goal of making decision-making processes more participatory.

Several key outcomes emerge from the presented case studies, which should be further explored and tackled in future projects. First, it is often the case that the engagement of stakeholders and participation of citizens informs the design of project objectives and the scope of interventions. For example, in Finnøy the engagement of the greenhouse industry informed the selection of renewable solutions to be implemented on the island.

Secondly, the behavior and characteristics of end-users are almost-always considered. A key example of this is the design of IHDs in the Bolzano smart city project. This greatly enriched project outcomes, increasing trust as a result of the co-creation process. However, it is also evident from the presented case studies that solutions are not always co-created. While there are clear examples such as the Knutsford precinct project where co-creation and engagement are central to the process, in other instances solutions were pre-defined before the start of any engagement process. An ideal participatory process would strive to co-create solutions, such as in our ENGAGED framework, however this is not always feasible in solar neighborhoods. This may be due to local opposition of renewable projects or simply governance structures that do not allow the time for a lengthy engagement process or shared decision-making between numerous stakeholders.

Thirdly, while behavior is often considered, behavior-change solutions such as nudges, boosts, or others are often overlooked in solar neighborhood planning. When such approaches are explicitly adopted, such as in the Bolzano smart city project, they are often applied in a top-down fashion. There were no examples in which any behavior change intervention was co-created or considered in the context of a participatory process. Moreover, in no cases was there explicit mention of behavior-change approaches being used to increase participation in engagement activities. Though task experts reported in several cases that posters and flyers were used, the design of these was never explicitly informed by behavioral science. This is an important missed opportunity, as there is a rich literature on increasing citizen participation in engagement activities by leveraging insights from behavioral economics, as detailed in Section 5.

Finally, testing of the outcomes and impacts of engagement activities could be improved. Although the outcomes of engagement activities were often monitored (number of participants, stakeholder groups reached out, etc.), it would have been preferable to follow-up with engaged stakeholders and citizens

through interviews and surveys ex-post to assess levels of trust and inclusion in the process that was perceived in the project.

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Front cover image credit: Eurac Research/Malou Reedorf.

9 Annex

Stakeholder engagement in Solar Neighborhood Planning.

Using stakeholder analysis and behavioral design to promote engagement in solar projects.

Note: This document aims at collecting examples on how stakeholder engagement techniques have been implemented in ongoing solar neighborhood projects, to inform deliverable DB.3. Therefore, we ask you to share some of your past experiences on projects in which engagement processes have been applied.

Name and aim of project: *What are the objectives of the project? What are the activities involving people outside the project (e.g.: communities, associations, etc.)?*

State of the project: *Has the project started yet? Is the project ongoing?*

Location: *What is the geographical context of this project?*

Case studies: *What and how many case studies are there?*

Stakeholder identification: *Which stakeholders were involved? How where they identified?*

Engagement objectives: *What were the reasons for involving these stakeholders?*

Engagement strategy: *What were the engagement techniques? What were the tools used (e.g.: interviews, focus groups, etc.)?*

Outcomes/behavioral design: *What were the outcomes of these activities? How were behavioral aspects such as the use of buildings considered? How did this inform the project?*

Difficulties/limitations: *What were the difficulties? - What could have been the problems?*

Figure 14: Template used to collect expert case studies on stakeholder engagement in solar neighborhoods.

EXAMPLE Case study: STARDUST (Trento, Italy)

	Interest			Influence		
Organisation, group or individual	Motivation of interest (ex: to improve the environment, to improve relationships, etc.) DESCRIBE	Nature of interest (ex: social, economic, environmental, etc.) DESCRIBE	Level of interest (High/Medium/ Low)	Nature of influence (positive influence) (ex: increase approval of the project, solve problems between different actors, have an accepted and established role in the community) DESCRIBE	Nature of influence (negative influence) (ex: cause conflicts, constitute a barrier, slow down project developments, etc.)	Level of positive influence (High/Medium/Low)
Association for elderly people	To improve relationships and creation of network	Social: increase trust among the residents of the neighbourhood	Medium	To increase approval of the project among elderly people	N.A.	Medium

	Impact			Power		
Level of negative influence (High/Medium/Low)	Nature of impact (ex: social, economic, environmental, etc) (describe)	Timing of impact (Short/Long)	Level of impact (High/Medium /Low)	Type of power (institutional, community, scientific, etc.)	Nature of power (influence the community, limit resources, etc.)	Level of power (High/Medium/Low)
N.A.	The elderly people can identify the association as a new social aggregation point and can spend more time in the association	Short and Long	High	Community	Facilitating communication between elderly people and partners of project	High

Figure 15: Stakeholder analysis example exercise presented in 1st workshop.

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