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Supporting the Development of Gendered Energy Innovations for Informal Urban Settlements: GENS Codesign Toolkit for Multistakeholder Collaboration

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Abstract: There is still little knowledge about the link between gender mainstreaming and energy security in informal urban settlements and there is limited design support to address this linkage. This paper presents the development and evaluation of the Gender for Energy Security (GENS) codesign toolkit, which was made to facilitate the design of gendered energy innovations for informal urban settlements. The toolkit was developed by applying the Design Research Methodology (DRM) and is grounded in the findings of a literature review, semi-structured interviews and ethnographic fieldwork in two informal urban settlements. The toolkit aimed to support codesign processes by providing its users with knowledge about the gendered energy scene in informal urban settlements and facilitating idea generation for gendered urban energy innovations. The evaluation of the GENS codesign toolkit was conducted during a one-day multistakeholder codesign workshop in Nairobi, Kenya. During the testing, we found that the toolkit was successful in facilitating energetic discussions, helping its users to learn about the gender–energy nexus in informal urban settlements and generate original ideas for gendered energy innovations. The toolkit is an addition to the current tools, handbooks and manuals on mainstreaming gender in the energy sector, with a unique focus on informal urban settlements and supporting idea generation.

Keywords: gender mainstreaming; energy security; urban households; informal settlements; design toolkit; codesign



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1. Introduction

Low-income areas in the Global South are disproportionately affected by energy insecurity [1,2]. This means that they lack the provision of sufficient energy required to meet the basic needs of their households' daily lives with minimal disruptions to supply and at an affordable price [3,4]. There is an increasing interest in understanding how energy poverty in low-income areas is affected by different social inequalities, including gender [5–7]. Lack of energy access is hindering gender equity and the empowerment of women [8]. For example, women and girls suffer from health problems associated with indoor cooking air pollution due to the use of smoke-emitting paraffin and biomass [9]; are often responsible for carrying out the time-consuming activity of fuel collection [10], and thus, drastically limiting the time that could be spent on education and income generation [11]; and are often responsible for ensuring reliable and continuous availability of energy in households [12], which also leads to the associated problems of handling low-quality unsafe energy devices [13,14].

For these reasons, it is crucial to consider gender at the core of energy interventions in order to avoid inequalities regarding aspects such as resources and income, as well as gender roles and responsibilities [15]. Thus, gender mainstreaming, which is defined as “the promotion of gender equality through its systematic integration into all systems and structures, into all policies, processes, and procedures, into the organization and its culture, into ways of seeing and doing” [16], must be pursued in order to allow both women and men to benefit from energy access [17].

However, despite the growing body of work on the gender–energy nexus, it must be highlighted that the focus is still limited to rural areas e.g., [8,18,19], while only a handful of studies explore how gender inequalities in informal urban settlements aggravate energy insecurity [20,21]. As pointed out by Musango et al. [5], energy insecurity is also affecting urban poor environments. In addition, in these environments, energy insecurity and unmet energy needs are aggravated by gender inequalities [22].

As a result, a potentially effective strategy to address this problem is to equip energy companies with knowledge and know-how on gender mainstreaming. In this respect, there are many design supports (toolkits, handbooks and manuals) that have been published to guide those seeking to develop energy solutions with gender mainstreaming in mind. However, existing supports are characterised by a lack of focus on informal urban settlements; a lack of focus on idea generation (or codesign) combining gender, energy and informal urban settlements; and a lack of practical applicability due to their extended length and/or required time-consuming preparations. This is confirmed by the interviews we carried out with 15 private companies operating in the sub-Saharan Africa energy sector [23], which showed that none of these companies had used or are using existing gender–energy nexus supports in their practice.

For these reasons, there is thus a clear gap that needs to be addressed: the absence of applicable and effective toolkits supporting idea generation for gendered energy innovations in informal urban settlements. We addressed this gap by developing and testing the first version of the Gender for Energy Security (GENS) codesign toolkit, which is a set of tools that were designed to equip private and public stakeholders for creating gendered energy solutions for informal urban settlements. This paper introduces this toolkit and discusses the results from the toolkit’s empirical application with the target users. We developed the toolkit to be used as a knowledge source, as well as an instrument for idea generation. Therefore, the aim of the GENS codesign toolkit is to enable energy companies and other stakeholders along the energy value chain to (1) learn about energy-related practices, issues and existing solutions for female and male energy users in informal urban settlements, and (2) generate ideas for energy solutions for informal urban settlements considering different issues, needs and capabilities of women and men. It must be highlighted that the toolkit targets those energy companies/organisations who focus on solutions to domestic energy needs (e.g., cooking, lighting, water heating, refrigeration, space cooling, space heating, washing and tool powering) and productive use of energy to support small entrepreneurship.

The GENS codesign toolkit was developed by the researchers from the Africa-UK Trilateral Research Project GENS (Gender for Energy Security). The project’s overall aim is to enhance the development of energy innovations that consider the different roles, responsibilities and needs of female and male energy users in African informal urban environments [5]. The final goal of the GENS project is to establish Living Labs in the GENS case study locations: Mathare (Nairobi, Kenya) and Groenheuwel (Paarl, South Africa) informal settlements. At GENS, we define a living lab as “a research and innovation concept for experimental and experiential learning in real-life environment, involving users and multiple private and public stakeholders, aimed at tackling the problem of energy insecurity in urban poor environments” [24]. The GENS Living Labs are stakeholder-driven spaces for learning about gender roles in energy-related activities; co-creating, testing and observing energy innovations; and scaling up these innovations towards improved gender mainstreaming in the energy sector [24]. We developed the GENS codesign toolkit with the GENS Living Labs

in mind as fundamental support that facilitates multistakeholder interaction throughout the above-listed learning, cocreation and implementation stages, taking place within and outside a living lab. However, the toolkit is also meant to be used outside these living lab environments.

The paper is structured into six sections. The next section outlines the methodology used to develop the GENS codesign toolkit and its application process. Section 3 introduces all tools included in the toolkit and the proposed codesign process associated with the toolkit. Section 4 describes the toolkit's testing during the multistakeholder codesign workshop. Section 5 discusses the findings and summarises improvements to be implemented in the next version of the toolkit. Section 6 concludes the paper.

2. Methodology: The Development and Evaluation of the GENS Codesign Toolkit

This section outlines the information collected to develop the contents of the toolkit and defines its application process and testing. Research activities were planned according to the Design Research Methodology (DRM), which is a framework for developing design supports [25]. Our research activities in relation to the DRM stages are described below. These activities are also summarised in Figure 1.

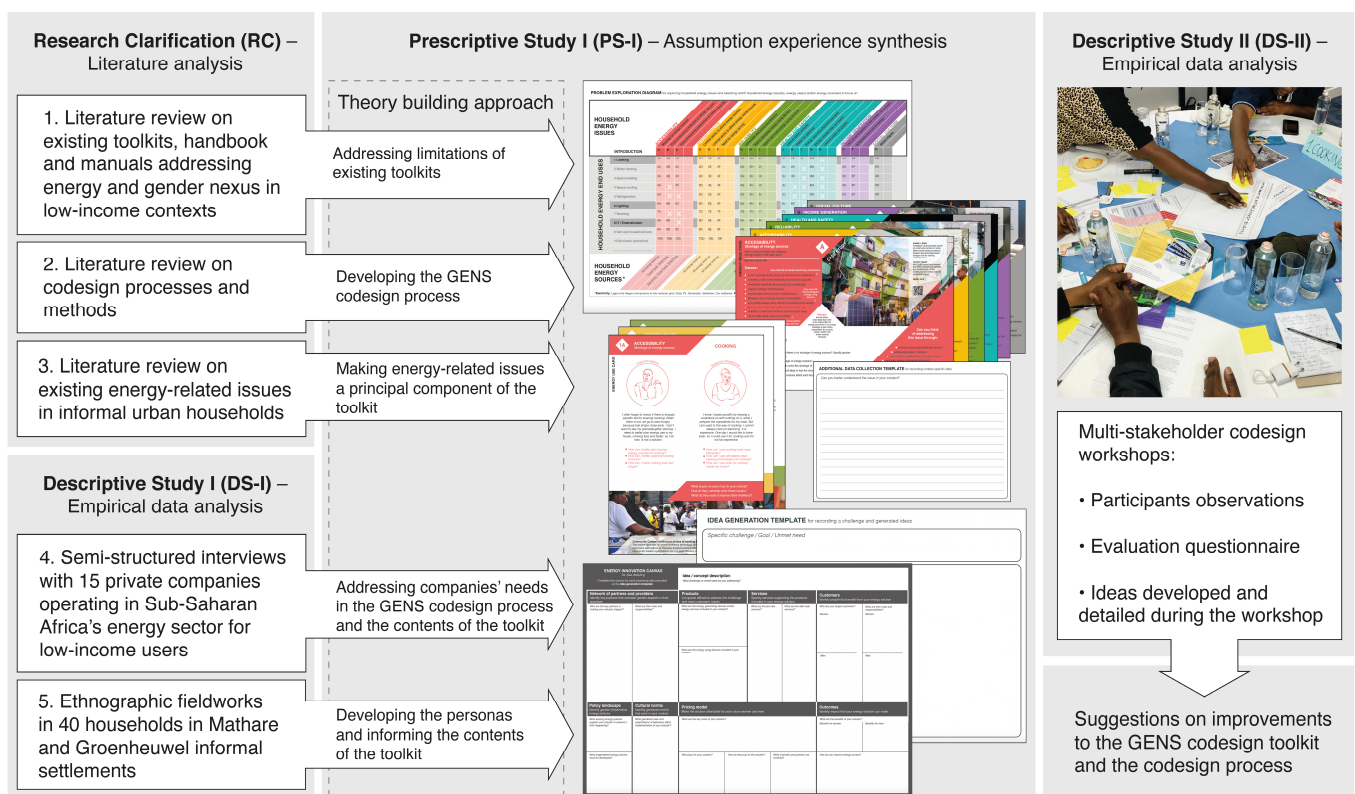


Figure 1. Design Research Methodology used to develop and evaluate the GENS codesign toolkit.

2.1. Research Clarification (RC)—Literature Analysis

Literature review on existing design supports (toolkits, handbooks and manuals) addressing the energy and gender nexus in low-income contexts. The aim was to understand what design supports are currently available for those wishing to design energy solutions with gender in mind and identify its limitations. The key search concepts were “energy”, “gender mainstreaming” and “design support”, and the specific Boolean phrase we used was as follows: (Energy) AND ((Gender) AND (Mainstream*) OR (Equality) OR (Equity) OR (Fairness) OR (Women)) AND ((Design) OR (Support) OR (Tool*) OR (Handbook) OR (Manual) OR (Method) OR (Guid*) OR (Project) OR (Training)). In simple terms, we searched for design supports that tackle the energy and gender nexus. The search was performed on

the web and in Google Scholar since we knew that these kinds of supports are usually found in the grey literature. The search resulted in 20 design supports published between 2004 and 2019 (see Appendix A for the complete list). These supports included toolkits, handbooks and manuals published by international organisations, such as USAID [26], ADB [27,28], ENERGIA [29–31] and UNDP [32,33]. These supports were targeted towards a wide spectrum of stakeholders (policymakers, consultants, community groups, private sector companies, the academic community, etc.), and included a combination of strategies, methods, best practices and principles on how to consider and integrate gender into energy projects. The literature review on existing design supports showed that only 1 out of 20 existing supports we analysed focused specifically on urban environments [26]. While 5 of our analysed supports served the training purpose [30,31,33–35] and 10 facilitated qualitative data gathering (e.g., [27]), none of the supports were designated for idea generation or codesign. Furthermore, containing up to 176 pages of information [35], these toolkits require time-consuming preparations, and thus, their practical applicability is questionable. This review enabled us to identify the research gap: the lack of an applicable and effective toolkit that supports idea generation for gendered energy innovations in informal urban settlements.

Literature review on codesign processes and methods. The GENS codesign toolkit was developed to be used in codesign activities, where different stakeholders from different sectors engage in gendered energy innovation processes [24]. Therefore, the aim of this literature review was to identify what to consider when developing a toolkit that enables codesign processes characterised by complex multistakeholder collaboration. We analysed implemented codesign studies (e.g., [36]) and looked at the importance of facilitation [37] and dialogue between participants [38,39]. The literature review on the codesign process and methods was helpful for outlining the toolkit's elements and the codesign process to be adopted by the toolkit.

Literature review on existing energy-related issues in informal urban households. Design is often used as a problem-solving activity that results in creative solutions [40]. Therefore, understanding what problems currently exist in the energy scene of informal urban settlements was identified as a crucial step towards context-specific energy innovations. We collected the energy-related issues and clustered them into six main areas:

- (1) Accessibility. This includes issues related to the shortage of energy sources (e.g., seasonal fuel availability [41]) and the time-consuming collection and preparation of energy sources (e.g., women spend four times longer than men collecting firewood [10]).
- (2) Affordability. This considers problems connected with the limited ability to afford energy sources (e.g., the price of the fuels is a major factor in determining the household's fuel preference and energy consumption [42]), limited ability to afford energy-using devices (e.g., where there is an electrical connection, the use of electricity for cooking or heating may be difficult due to a high additional appliance cost [43]) and the need for energy saving (e.g., limiting the number of cooking times to reduce costs [12]).
- (3) Reliability. This refers to aspects associated with unreliable electricity connections (e.g., [44]), poorly designed and serviced energy-using devices (e.g., poorly designed clean cooking appliances age and break easily, and this is combined with the lack of after-sale services, such as maintenance and repair [13]).
- (4) Health and safety. This includes problems related to the lack of safety at home and on the streets (e.g., crime in the community because of the lack of street and public toilets lighting), indoor air pollution (e.g., due to lack of modern cooking systems [45]), energy sources effect on food taste (e.g., paraffin affects the taste of food when used for cooking [9]), and energy-related risks for health (e.g., accidental fires from the use of candles and kerosene stoves [42]).
- (5) Income generation. This is about the lack of opportunities for women to be involved in the energy value chain (e.g., relevant roles within energy companies) and entrepreneurial activities [11].

- (6) Social culture. This is related to the stigma associated with using or not using certain energy sources (e.g., in certain Kenyan communities, it is believed that charcoal is the best option for cooking certain traditional meals [42]).

The collected issues were included in the contents of the GENS codesign toolkit and informed the following data collection stages.

2.2. Descriptive Study I (DS-I)—Empirical Data Analysis

Semi-structured interviews with 15 private companies operating in sub-Saharan Africa's energy sector for low-income users. We believe that private energy companies that offer products and services to the residents in informal settlements are catalysts for change and primary users of the GENS codesign toolkit. We conducted one-hour semi-structured interviews that aimed to understand how companies design energy solutions and what (design) supports they use. The interviews were focused on discussing the following: (1) the gendered aspects that companies currently consider in the different stages of the design of energy solutions; (2) the methods and tools used and expertise involved in the design of energy solutions; and (3) the considerations they make when designing for informal urban areas, including energy-related issues addressed by the companies. We found out that the focus on gender is still limited among energy companies, and the application of readily available gender–energy nexus tools is non-existent [23]. However, companies are eager to learn about gender in energy and receive strategic design support to better mainstream gender in their energy projects. In-depth interview findings are presented and discussed in a working paper. The interview results were used to finalise the design process using the toolkit and contributed to the contents of the toolkit.

Ethnographic fieldwork in 40 households in Mathare (Kenya) and Groenheuwel (South Africa) informal settlements. The aim of the ethnographic data collection was to gain insight into how residents of the GENS case study locations manage energy-related issues identified from the literature review and semi-structured interviews. We applied remote rapid ethnographic data collection [46], which was conducted by the locally based community co-researchers from Mathare and Groenheuwel. Co-researchers worked in pairs and spent half a day in each household to (1) observe how women and men used energy devices, sources and services in their daily lives; (2) question the residents to reveal their unmet energy needs; and (3) collect ideas regarding energy solutions that were generated by people living in the settlements. The ethnographic data collection findings informed the development of personas—i.e., fictional characters representing different users—and were included in the contents of the codesign toolkit. Furthermore, the employment of community co-researchers strengthened the relationship between the GENS project and the communities, which is fundamental for the successful establishment of the GENS Living Labs and the organisation of multistakeholder activities.

2.3. Prescriptive Study I (PS-I)—Assumption Experience Synthesis

Data gathered during the RC and DS-I stages were used to develop the GENS codesign toolkit and its application process. We applied the theory-building approach [47] to synthesise the collected data into individual tools (combined to form a toolkit) and defined the toolkit's application codesign process. This process was inspired by the double diamond design approach (DDDA), which suggests exploring an issue “widely or deeply” and later, based on the exploration, taking a focused action [48].

2.4. Descriptive Study II (DS-II)—Empirical Data Analysis

The first version of the GENS codesign toolkit was tested during a full-day codesign workshop held in Nairobi, Kenya, in December 2021. The activity was facilitated physically by three GENS researchers from Brunel University London, the University of Nairobi and Stellenbosch University. The aim of the testing was to evaluate the toolkit's performance with its target users and observe the dynamics of the proposed codesign process. Three mixed data collection methods were applied to gather feedback about the

toolkit's performance during the workshop: researchers' observations (qualitative data), participants' evaluation questionnaire (qualitative and quantitative data), and ideas developed and detailed during the workshop (qualitative and quantitative data). Qualitative data were analysed using thematic coding and classifying data into codes and themes to generalise gathered insights and ideas [49]. Quantitative data were analysed using a prescriptive statistics percentage tool [50] to define the proportion of people who gave a specific evaluation.

Based on the DRM, an evaluation questionnaire was made to evaluate the following of each element of the GENS codesign toolkit: (1) completeness: the extent to which the toolkit contains logical and detailed content about gender, energy and informal urban settlements; (2) usability: the extent to which the toolkit is easy to understand and apply; and (3) effectiveness: the extent to which the toolkit enables users to understand current energy-related issues and generate gendered energy ideas for informal urban settlements.

3. GENS Design Toolkit

This section outlines the elements of the GENS codesign toolkit and describes the proposed codesign process.

3.1. Elements of the Toolkit

The first version of the GENS codesign toolkit consists of six tools: a problem exploration diagram, a set of 17 energy issue cards, a set of 45 energy end-use cards, an additional data collection template, an idea generation template and an energy innovation canvas. All tools were made to be printed out to be easily shared among users, studied and evaluated during the toolkit's testing activities. The relations between these six tools and how they support the proposed codesign process are described in Section 3.2.

3.1.1. Problem Exploration Diagram

The purpose of the problem exploration diagram is to help users to explore existing energy-related issues in informal urban households and their linkages with different energy sources. It is the introductory tool of the toolkit, and thus, it was made to provide an overview of a wide variety of issues that can be tackled by the toolkit. Furthermore, it helps to navigate the toolkit by referring to those cards to be used for further problem exploration and idea generation. The list of 17 issues included in the diagram was informed by the findings from the literature review, interviews with energy companies and ethnographic data collected in Mathare and Groenheuwel informal settlements. The layout of the diagram was designed to highlight the household energy issues; thus, six different block colours were used to represent the six identified categories of the issues. Figure 2 shows the problem exploration diagram and its key components.

3.1.2. Energy Issue Cards

The aim of the energy issue cards is to provide in-depth information about each of the household energy issues listed on the problem exploration diagram introduced above. In addition, it was made to support idea generation. There is a total of 17 energy issue cards, one for each issue named from A to R. The information listed on the cards was informed by the literature review findings, ethnographic data collection and insights gained from the interviews with energy companies. Each colour used on the card refers to a category of household energy issues addressed on the card. Figure 3 illustrates one of the energy issue cards and summarises its key features.

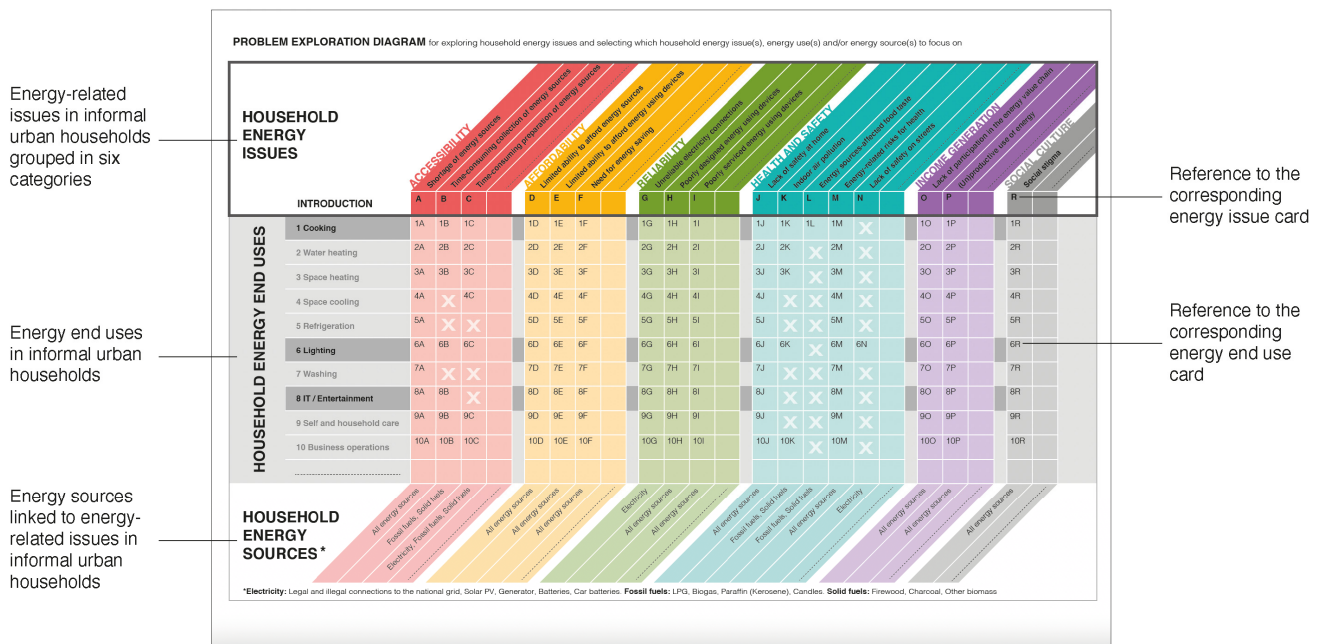


Figure 2. Problem exploration diagram printed on an A3-sized piece of paper.

Figure 3. One of the seventeen energy issue cards printed on an A5-sized piece of paper.

3.1.3. Energy End-Use Cards

The goal of the energy end-use cards is to provide a first-hand user experience about household energy issues for different energy end uses. The cards includes persona stories that were collected during the ethnographic research in Mathare and Groenhuwel informal settlements: each card contains one persona from each settlement, either a woman or a man. The energy and use cards were also made to support idea generation. The vertical layout of the cards was chosen to differentiate the cards from the energy issue cards. In order to maintain consistency, the single colour used on the card refers to the category of the household energy issue. The first version of the toolkit includes the cards addressing cooking, lighting and IT/entertainment energy end uses. Figure 4 pictures one of the energy end-use cards with its key components.

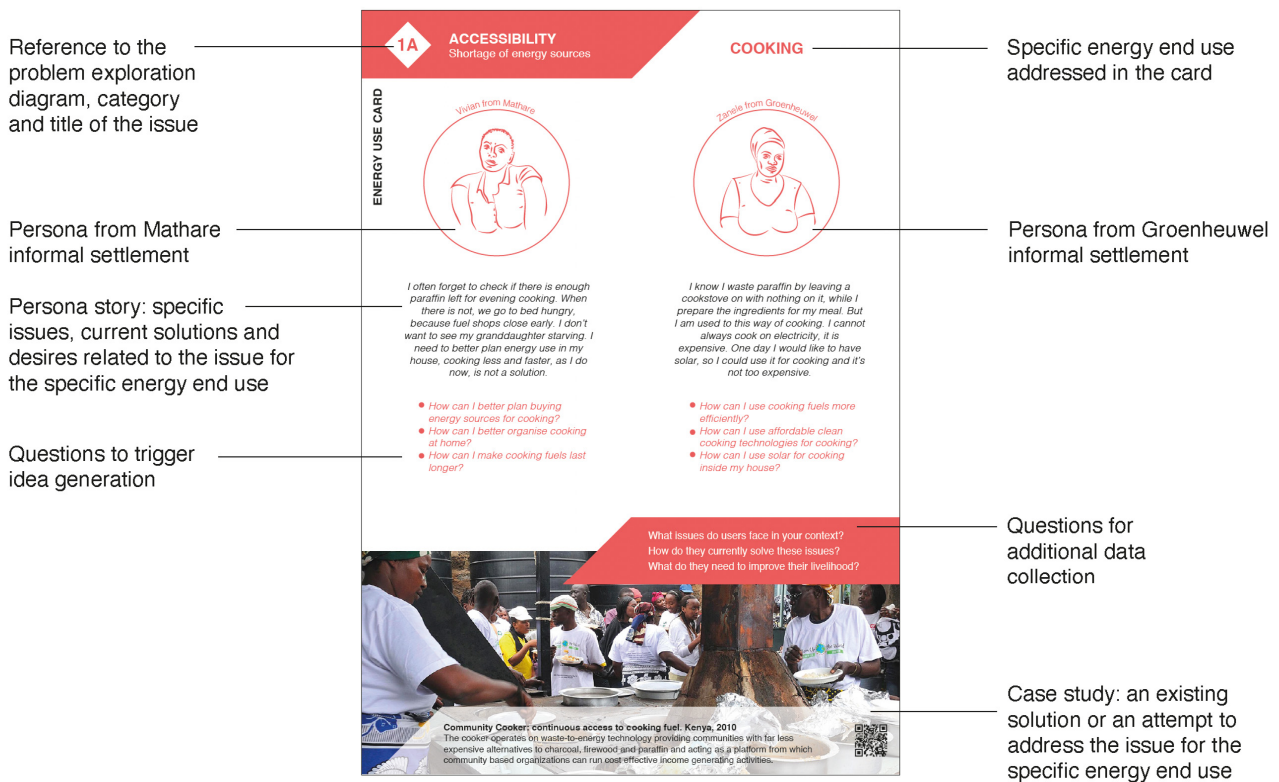


Figure 4. One of the forty-five energy end-use cards printed on an A5-sized piece of paper.

3.1.4. Additional Data Collection Template

The purpose of the additional data collection template (Figure 5) is to provide space for the users to collect context-specific data about household energy issues. This template was made to record answers to data collection questions listed on the energy issue cards and energy end-use cards.

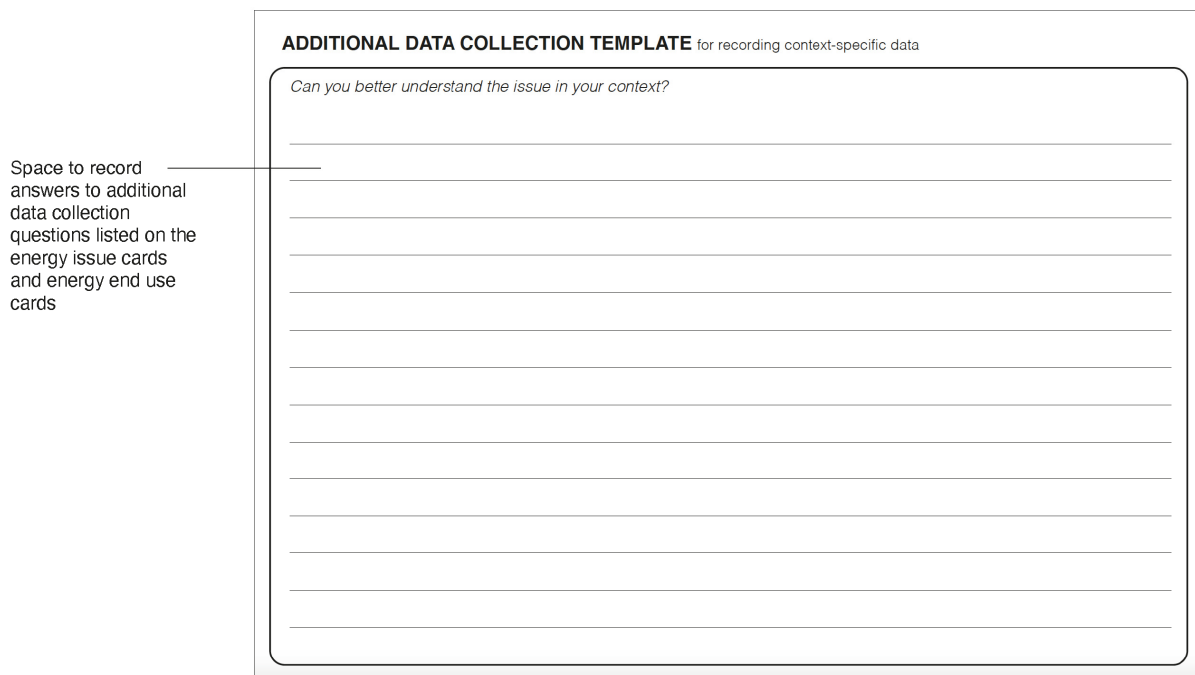


Figure 5. Additional data collection template printed on an A5-sized piece of paper.

3.1.5. Idea Generation Template

The idea generation template (Figure 6) is a space for describing a specific design challenge and recording ideas addressing the challenge.

IDEA GENERATION TEMPLATE for recording a challenge and generated ideas

Specific challenge / Goal / Unmet need

Ideas addressing the challenge

Space to specify a challenge related to household energy issues from the problem exploration diagram

Space for post-it notes

Figure 6. Idea generation template printed on an A3-sized piece of paper.

3.1.6. Energy Innovation Canvas

The purpose of the energy innovation canvas (Figure 7) is to describe the essential elements of the most promising idea(s) listed on the idea generation template and to understand their viability for further development and implementation. The canvas was adapted from the famous Business Model Canvas [51] and supplemented with the GENS research project-specific sections, including the energy policy landscape, cultural norms, and social and environmental outcomes.

ENERGY INNOVATION CANVAS
for ideas detailing

Complete this canvas for each promising idea recorded on the idea generation template

Network of partners and providers
Identify key partners that consider gender aspects in their practices

Who are the key partners in making your solution happen?
What are their roles and responsibilities?

Products
List goods offered to address the challenge and final customers' needs

What are the energy generating devices and/or energy sources included in your solution?
What are the energy using devices included in your solution?

Services
Specify services supporting the products included in your energy solution

What are the pre-sale services?
What are the after-sale services?

Policy landscape
Identify gender (in)sensitive energy policies

What existing energy policies support your solution or prevent it from happening?
What engendered energy policies must be developed?

Cultural norms
Identify gendered norms that exist in your context

What gendered rules and expectations of behaviour affect engagement of your solution?

Pricing model
Make the solution affordable for poor urban women and men

What are the key costs of your solution?
Who pays for your solution?
How do they pay for the solution?
What channels and partners are involved?

Customers
Identify people that benefit from your energy solution

Who are your target customers?
Women:
Men:

Outcomes
Identify impact that your energy solution can make

What are the benefits of your solution?
Benefits for women:
Benefits for men:
How do you improve energy access?

Areas of strategic detailing of the selected idea

Questions facilitating completion of each area

Space to describe the idea selected from the idea generation diagram for further detailing and potential implementation

Figure 7. Energy innovation canvas printed on an A2-sized piece of paper.

3.2. The GENS Codesign Process Using the Toolkit

Based on the double diamond design approach (DDDA) [48] and addressing the purpose of the GENS Living Labs, we defined the GENS codesign process as comprising three main stages (Figure 8):

1. **Problem exploration stage (equivalent to the “discover” and “define” stages of the DDDA).** Tools: problem exploration diagram, energy issue cards, energy end-use cards and additional data collection template.

During this stage, the toolkit’s users learn about existing energy-related issues in informal urban households, the causes of these issues, and the effects on both genders and current solutions implemented to address these issues. During this stage, users are also encouraged to collect additional context-specific data to better understand how the issues listed in the toolkit affect users from the targeted informal settlement. At the end of this stage, users define a specific problem to focus on in the next stages.

2. **Idea generation stage (equivalent to the “develop” stage of the DDDA).** Tools: *energy issue cards, energy end-use cards and idea generation template.*

The second stage is dedicated to generating ideas that address the specific problem defined in the previous problem exploration stage. During this stage, the toolkit’s users brainstorm a wide range of ideas and, if needed, go back to the problem exploration stage to gain additional information and inspiration.

3. **Idea detailing stage (equivalent to the “deliver” stage of the DDDA).** Tools: *idea generation template and energy innovation canvas.*

During the final stage, the toolkit’s users select one idea or a set of ideas developed in the previous stage that they see the most potential in implementing. They think about the enabling environment needed to make their selected idea a reality and its effects on society and the environment. At the end of this stage, the toolkit’s users have an overview of the range of aspects of their final ideal, including products, services and the supporting infrastructure.

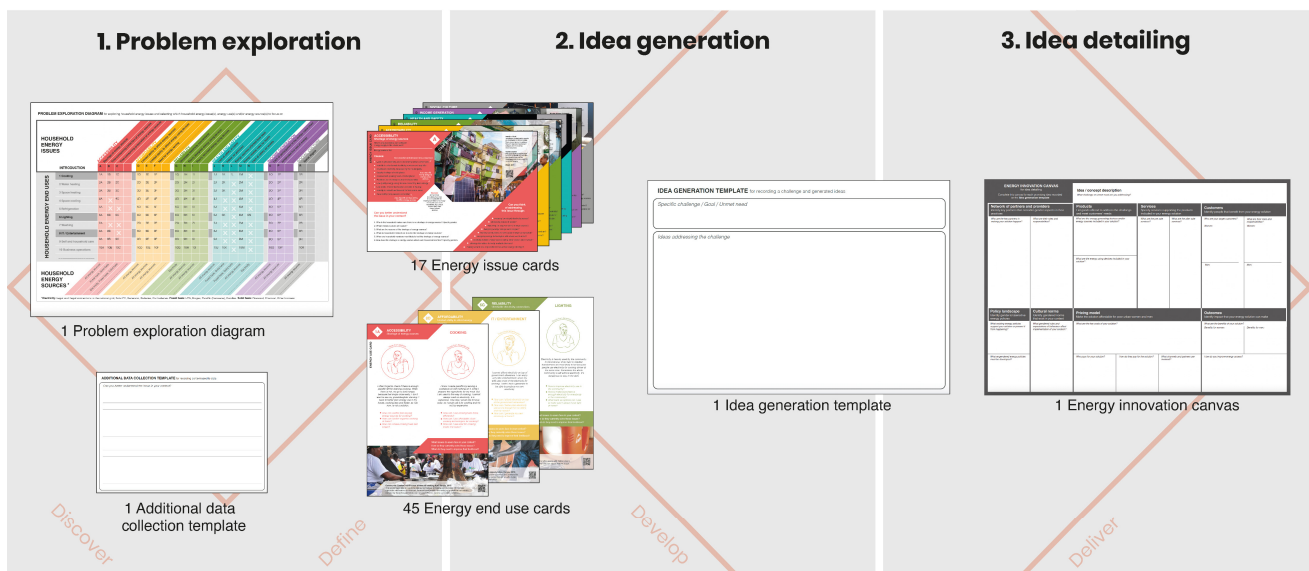


Figure 8. The elements of the GENS codesign toolkit in relation to the corresponding stages of the GENS codesign process and the double diamond design approach.

4. Case Study: The GENS Codesign Workshop

The GENS codesign workshop invited community members from Mathare informal settlement, as well as private and public stakeholders, to codesign gendered energy solutions for Mathare residents. The participants were representative of the toolkit’s intended

audience: multiple stakeholders interested in solutions to sufficiently meet the energy needs in informal settlements. In total, 25 participants—15 women and 10 men—took part in the workshop. The participants were recruited via email. More than half of the participants attended previous stakeholder engagement activities organised by the GENS researchers, and thus, they already knew each other and the GENS team. All participants were able to speak English and Swahili.

At the beginning of the workshop, the participants were split into five multistakeholder groups of between four and six members. Each group included representatives from one of the five private companies and Mathare community and either a researcher or a policymaker (Table 1).

Table 1. Stakeholders who attended the codesign workshop.

Stakeholder's Code and Group Allocation		Sector	Role	Gender
PC1	Group 1	Private company (a)	Solar technician	Female
PC2	Group 1	Private company (a)	Solar technician	Male
PC3	Group 1	Private company (a)	Operations officer	Female
PC4	Group 2	Private company (b)	Sales and experiential manager	Female
PC5	Group 2	Private company (b)	Customer care	Female
PC6	Group 3	Private company (c)	Strategy coordinator	Female
PC7	Group 3	Private company (c)	Business development	Female
PC8	Group 3	Private company (c)	Head of legal compliance	Female
PC9	Group 4	Private company (d)	Product manager	Female
PC10	Group 4	Private company (d)	Product manager	Female
PC11	Group 5	Private company (e)	Grants and impact manager	Female
MC1	Group 1	Mathare community	Community leader	Male
MC2	Group 1	Mathare community	Energy user	Female
MC3	Group 2	Mathare community	Energy retailer	Male
MC4	Group 2	Mathare community	Community leader	Male
MC5	Group 3	Mathare community	Energy retailer	Male
MC6	Group 3	Mathare community	Community leader	Female
MC7	Group 4	Mathare community	Community leader	Male
MC8	Group 5	Mathare community	Energy retailer	Female
MC9	Group 5	Mathare community	Energy user	Male
RS1	Group 2	Research institute (a)	Researcher	Male
RS2	Group 3	Academia (a)	Lecturer and researcher	Male
RS3	Group 4	Research institute (b)	Executive director	Female
RS4	Group 5	Academia (b)	Researcher	Female
GV1	Group 5	Government	Policymaker	Male

The workshop lasted 5 h 30 min excluding breaks. The structure of the workshop (Table 2) was organised to follow the GENS codesign process introduced in the section above. At the beginning of the workshop, the facilitator from Brunel University London presented the background information about energy (existing household energy issues), gender (best practices and principles for gender mainstreaming in the energy sector) and informal urban settlements (overview of Mathare and Groenheuwel). Finally, the GENS codesign toolkit was introduced and circulated to the participants. Later, each participating group was asked to select one design brief to focus on for the duration of the workshop.

Three design briefs, addressing focus areas of participating companies and energy end uses included in the toolkit—cooking, lighting and IT/entertainment—were suggested by the facilitator:

- (1) Design a clean cooking solution for indoor cooking using waste as a resource (selected by two groups);
- (2) Design an outdoor lighting system for improved safety in the settlement (selected by one group);
- (3) Design a communal entertainment system for the whole family (selected by two groups).

Table 2. The agenda of the GENS codesign workshop.

Stage	Activity	Duration
Introductions by the facilitator	Presentation on the household energy issues in informal settlements	60 min
	Presentation on the best practice principle for gender mainstreaming in the energy sector	
	Presentation on comparison between Mathare and Groenheuwel informal settlements	
	Introduction to the GENS codesign toolkit	
Problem exploration in groups	Selection of design briefs by the participants	60 min
	Selection of three household energy issues to address from the problem exploration diagram and analysis of the energy issue cards	
	Additional data collection (by answering questions on the energy issue cards)	40 min
	Analysis of energy end-use cards	
	Additional data collection (by answering questions on the energy end-use cards)	
Idea generation in groups	Idea generation	60 min
	Presentations of populated idea generation diagrams	25 min
Idea detailing in groups	Idea selection for detailing	40 min
	Idea detailing using the energy innovation canvas	25 min
	Presentations of the populated energy innovation canvas	
Feedback	Discussion and feedback using evaluation questionnaires	20 min

After selecting the design briefs, the participants were ready to follow the step-by-step codesign process guided by the facilitators (Figure 9). Each group had to identify which of the three household energy issues listed on the problem exploration diagram they wanted to address (1). Participants discussed the information provided on the diagram and energy issue cards. After deciding the three issues to focus on, they were asked to better understand these issues in relation to the Mathare context by questioning group members and recording answers on the additional data collection templates (2). The same process was repeated with the energy end-use cards (3). After the problem exploration was finalised, the groups started generating ideas addressing the three selected issues. The groups populated three idea generation diagrams each (4) and presented them during group presentations. The final stage was idea selection and detailing. Participants had to select the most promising of their generated ideas and combine them in one energy innovation canvas per group (5). The workshop was concluded with group presentations on final detailed ideas. This was followed by a collective discussion on the toolkit and the collection of the evaluation questionnaire (6).



Figure 9. The toolkit's application during the codesign workshop. (1) Identification of energy issues to address; (2) Discussing the information provided on the diagram and energy issue cards; (3) Discussing the information provided on energy end-use cards; (4) Generating ideas and writing them down on the idea generation diagrams; (5) Selecting and detailing ideas and combining them in one energy innovation canvas; (6) Presenting results.

4.1. Findings from the GENS Codesign Workshop

This section presents findings from three data collection methods: researchers' observations, participants' evaluation questionnaire, and ideas developed and detailed during the workshop.

4.1.1. Observations of the Workshop Participants

Participant observations were carried out by the facilitators throughout the problem exploration, idea generation and idea detailing stages of the codesign process. The aim was to collect qualitative insights on participants' behaviour during the use of the toolkit to assess the design of the codesign workshop. The facilitators moved between the tables listening to group conversations and noting down all noticeable insights. Insights from the facilitators' personal observations were linked to the workshop design and facilitation itself, group work dynamics and participant engagement, and the process of using the GENS codesign toolkit.

Workshop design and facilitation. First, it was observed that during the workshop, the participants kept on referring to the contents of the presentations given by the facilitators. Second, even though the facilitators guided the participants through the different elements of the toolkit throughout the workshop, the participants required extra clarification on how to select household energy issues and adapt the idea generation questions listed on the cards to a specific design brief they chose to address. Third, it was observed that two participating groups used some elements of the toolkit slightly differently from how it was explained by the facilitators: one group started by reading all energy issue cards instead of first selecting the issues from the problem exploration diagram to focus on, while the other group generated ideas for all three selected issues simultaneously rather than one at a time. However, both groups achieved the required results by the end of the workshop.

Groupwork and participant engagement. Energetic discussions between the group members were easy to notice, as the whole venue became noisy once the first group task—the selection of a design brief—was introduced. It was observed that the toolkit helped par-

ticipants from different backgrounds to communicate: the contents of both types of cards worked as a conversation starter and helped participants to open up and share ideas. Even though the contents of the toolkit were written in English, the participants discussed them in both English and Swahili. It was observed that the involvement of Mathare community members made the group work particularly lively because other stakeholders were interested in better understanding the context by questioning the community members. The community representatives also informed the choice of household energy issues. However, not all the participants were fully engaged in the group work. RS1 was more interested in reading through the toolkit's materials on his own rather than engaging in the group discussions. Later, he shared that the toolkit was very relevant to his personal work, and thus, he was fascinated by the amount of information it provided. In another group, the participation of the energy provider was vague, which was most likely caused by the very talkative researcher who took the lead. The lack of participant engagement could be addressed by supportive and sensible facilitation.

The use of the GENS codesign toolkit. The researcher who praised the contents of the toolkit was not the only participant who found the data of the toolkit interesting. It was observed that the case studies included in the cards helped the participants to understand the rest of the contents of the cards without having sufficient English language skills. PC9 had previous experience using various design tools and complimented the case studies as a particularly informative element of the GENS toolkit. In addition, group conversations and presentations considered gendered aspects, showing that the toolkit encouraged gender-focused thinking. During informal conversations after the workshop, energy providers from two companies expressed their interest in applying the toolkit in their companies' work.

Despite the positive comments and enthusiasm from the participants, observations also revealed a few limitations of the toolkit. Some participants struggled to understand the data collection and idea generation questions written on the cards; they had to read the same question more than once. Some participants had questions on how to complete the energy innovation canvas and suggested that the canvas could include possible options to choose from: e.g., PC10 was not sure what to include in the "Service" section. Finally, it was observed that the problem exploration diagram and the idea generation template printed on the A3-sized paper were too small, as participants found them difficult to share and read.

4.1.2. Toolkit's Evaluation Questionnaire


The evaluation questionnaire was designed to assess the completeness, usability and effectiveness of the GENS codesign toolkit and its individual elements. The questionnaire consisted of quantitative closed-ended scale questions and qualitative open-ended questions. Each participant was handed a printed copy of the questionnaire to be completed at the end of the workshop. Qualitative feedback was divided into positive comments praising the toolkit and its individual elements, suggestions for improvements and negative comments criticising the toolkit without suggesting improvements.

(1) All Elements of the GENS Codesign Toolkit

Gendered perspective included in the toolkit. All aspects of the whole toolkit received very high evaluation scores (Table 3). The toolkit's ability to provide a gendered perspective was praised by the participants: "So far this is the most integrated gender toolkit for product design I'm so excited to keep using it" (PC9). The feature of how the toolkit incorporated gendered perspectives was evaluated 4.56 out of 5, meaning there was still room for improvement. The participants noticed the absence of considerations regarding how energy affects different age categories of both genders. In terms of the contents, the participants found the case study descriptions too generic: "Some innovations, concepts are a little generalised. I think we can only be intentional by intentionally involving both genders" (PC2). The community members suggested focusing more on gender involvement in the energy value chain, particularly in the installation and maintenance stages. In terms of the

workshop design, the participants suggested that both genders should have equal rights to speak about their issues and express their views on design.

Table 3. Quantitative evaluation of the features of the GENS codesign toolkit.

Features Evaluated	Question	Score (out of 5)
 Completeness, usability and effectiveness	To what extent is the gender perspective included in the toolkit (i.e., issues, needs, solution etc. of women and men energy actors?)	4.56
	To what extent is the toolkit helpful to understand the energy context of informal urban areas?	4.72
	To what extent was the toolkit helpful to facilitate discussion in your group?	4.75

Energy context of informal urban settlements presented in the toolkit. The toolkit was found to be a useful source for helping understand the energy context of the informal settlement: “I think I got to understand the energy situation in poor urban areas in a way that has not been explored before. Having actors from those regions was a huge bonus” (PC7). The participants requested more context-specific information to be included in the toolkit, such as images from the settlement and descriptions of current “initiatives in place to address energy issues or any upcoming initiatives” (PC8). The participants were also interested in seeing the context-specific statistics. In terms of the workshop design, the participants would like to see more actors from each role in the energy sector and a stronger representation of the community members.

Facilitation of group discussion. The toolkit’s ability to facilitate group discussion received the highest evaluation score (4.75/5): “Very useful for getting diverse perspectives to collaborate” (RS3). Discussions were so engaging that the participants found the workshop too short for the number of activities and discussion points they had to complete: “Having enough time for discussion in order to allow everybody to give his/her opinions” (MC5). In addition, the participants suggested having a skilled facilitator in every group to guide the discussion and ensure the inclusivity of ideas.


(2) Problem Exploration Diagram

Completeness. Some participants found the problem exploration diagram complete: “The diagram was very comprehensive in content” (MC9), while others suggested adding more details, such as real-world examples and images: “it could be more specific and detailed” (MC8). However, the participants agreed that “with proper guidance received from the facilitator it was easier to comprehend and use [it]” (PC11). Finally, the issue of sustainability, which was perceived as critical by the participants, was not directly considered in the diagram.

Usability. The colours and overall layout of the diagram were complimented by the participants: “The diagram was very easy to use by an ordinary person in the urban poor areas” (MC1). The usability feature of the problem exploration diagram received the lowest evaluation point of all elements of the toolkit, yet still high (4.24/5) (Table 4). The participants expressed their dissatisfaction regarding the small text size that made the legibility of the diagram difficult and requested more than one copy per group. The participants also suggested testing the diagram with colour blind and short-sighted people.

Effectiveness. Despite the contents and usability limitations, the diagram was effective in helping to explore and select energy issues (4.6/5): “I think the diagram covers a large scope and it’s been compressed to cover everything nicely and still be understood” (PC1). The participants emphasised the importance of having sufficient use guidelines and facilitation since the diagram “might seem overwhelming at first” (PC3).


Table 4. Quantitative evaluation of the features of the problem exploration diagram.

Feature Evaluated	Question	Score (out of 5)
	Completeness To what extent are the contents of the diagram complete (i.e., included household energy issues, energy end uses and energy sources)?	4.29
	Usability To what extent is the diagram easy to read and use (in terms of layout/colours/shapes etc.)?	4.24
Effectiveness	To what extent is the diagram helpful to explore existing household energy issues?	4.6
	To what extent is the diagram helpful to select household energy issues, energy end uses and energy sources for further exploration and idea generation?	4.58

(3) Energy Issue Cards and Additional Data Collection Template

The energy issue cards were the most successful part of the toolkit according to the quantitative evaluation score given by the workshop participants (Table 5).

Table 5. Quantitative evaluation of the features of the energy issue cards and the additional data collection template.

Feature Evaluated	Question	Score (out of 5)
	Completeness To what extent are the contents of the cards complete (i.e., causes of the issue, gender insights, idea generation and data collection questions, case study example)?	4.68
	Usability To what extent are the cards easy to read and use (in terms of layout/colours/shapes etc.)?	4.68
Effectiveness	To what extent are the cards helpful to learn about household energy issues?	4.76
	To what extent are the cards helpful to generate ideas?	4.84

Completeness. The participants' opinions differed on the contents of the energy issue cards. Some of them found that the cards contained too much information and too many questions: "Look at reducing the areas, especially questions to answer given the limited time" (PC10). The other participants requested additional information, such as more roles of each gender, the aspects of government involvement in the energy sector and more context-specific case studies.

Usability. The community members found the cards easy to understand because of the simple English language used to explain their contents. However, similarly to the problem exploration diagram, the participants requested larger text sizes and more copies of the cards to be provided to each group to facilitate legibility and sharing. Additionally, the usability could be improved by including use guidelines: "My eyes weren't quite sure where to start so perhaps there could be an arrow just for easier/quicker comprehension" (PC9). One community member suggested combining the cards with the additional data collection template by adding a context-specific comment section to the cards.


Effectiveness. The cards' ability to help generate ideas received the highest evaluation score (4.84/5) out of all the elements in the toolkit. The participants found the case studies particularly insightful and helped to trigger ideas: "The global examples on the cards were excellent in helping teams think out of the box" (PC7); in terms of discussing the idea generation questions: "The specific questions really focused the conversation" (PC4).

(4) Energy End-Use Cards and the Additional Data Collection Template

It was observed during the workshop that the persona stories made the energy end-use cards educational and engaging: *“Best part of the toolkit!”* (RS1). *“I think I had a better experience with these cards than the previous”* (MC5).

Completeness. Several participants agreed that the energy end-use cards were complete: *“They should remain just like as they are”* (MC7), *“No additions are needed”* (PC4). The contents of the cards received an evaluation score of 4.6 out of 5 (Table 6), and thus, could be improved. The participants highlighted the lack of gender considerations in the cards: *“Let the questions have a gender component. Ask the question for a woman and the same question as it applies to men”* (PC2); they also demanded more context-specific case studies.

Table 6. Quantitative evaluation of the features of the energy end-use cards and the additional data collection template.

Feature Evaluated	Question	Score (out of 5)
	To what extent are the contents of the cards complete (i.e., persona stories, idea generation and data collection questions, case study example)?	4.6
	To what extent are the cards easy to read and use (in terms of layout/colours/shapes etc.)?	4.68
Effectiveness	To what extent are the persona stories helpful to learn about household energy issues for specific household energy end use?	4.8
	To what extent are the cards helpful to generate ideas?	4.68

Usability. The overall layout and the colours used in the cards were complimented by the workshop participants: *“The colours are bright enough for one to read”* (MC2). However, the small text size and the lack of copies provided to each participating group were criticized by the participants. The additional data collection template could include more instructions on how to use it.

Effectiveness. The educational aspect of the persona stories included in the cards received the highest quantitative evaluation (4.8/5). The participants requested more stories from other African countries: *“The stories help us understand the energy situation in different countries and so we are able to develop innovations that cut across”* (PC8). However, the participants pointed out the lack of linkage between the specific challenge they chose to address and the questions listed on the cards: *“It was a little confusing when we had to address the challenge and didn’t really quite figure out the questions in relation to persona and the challenge being addressed”* (RS4).

(5) Idea Generation Template

All features of the idea generation template received relatively high evaluation scores (Table 7), making it the third most successful tool across both types of cards.


Completeness. The participant feedback regarding the contents of the template was very positive, with most of the comments expressing satisfaction about its completeness: *“Nothing can be improved”* (MC4), *“It is good and organised no need to change anything”* (MC8). One researcher suggested including the identification of the actor network as the next step after idea generation.

Usability. In terms of usability, the workshop participants requested that the template be larger, followed by increased text size, so that more ideas can be recorded. The partic-

ipants, used to colourful tools they used previously, suggested including colours in the template: “*Stop making it look like an exam paper*” (MC2).

Effectiveness. In addition to idea generation, the template was also made to describe a challenge and help to select a promising idea(s) for further development. RS2 highlighted that it is a “*good way to group ideas by solution. Sticky notes really helped*”. However, the template’s ability to support idea selection could be improved: “*Use stage wise selection of ideas-start with a bigger number and applying a set criterion reduce them until you have the most critical ones.*” (GV1). The participants suggested that the workshop design could ensure that everybody explains their opinions alone, while the presentations are recorded for future use.

Table 7. Quantitative evaluation of the features of the idea generation diagram.

Feature Evaluated	Question	Score (out of 5)
	Completeness To what extent are the contents of the template complete?	4.76
	Usability To what extent is the template easy to read and use (in terms of layout/colours/shapes etc.)?	4.6
Effectiveness		To what extent is the template helpful to record a challenge?
	To what extent is the template helpful to record ideas?	4.79
	To what extent is the template helpful to select promising ideas for further detailing?	4.75


(6) Energy Innovation Canvas

Completeness. The workshop participants complimented the comprehensiveness of the canvas and compared it to the Business Model Canvas, with which most of them were familiar: “*The content is elaborated, nothing to be improved*” (MC2), “*I like this better than the business model canvas*” (RS3). However, several participants found the contents of the canvas repetitive. The customers’ section was named as ambiguous for some ideas, and the participants suggested that the canvas could be customised depending on the ideas. Furthermore, the participants highlighted the absence of the aspect of sustainability and social issues.

Usability. The participants found the canvas “*great and easy to use. It has a natural flow*” (PC10). The comments regarding the usability of the canvas were similar to the ones directed to the idea generation template: the participants requested more colours “*to make it exciting*” (PC3) and more space in each section. PC10 suggested that the usability could be facilitated by numbering a suggested route for completing the diagram.

Effectiveness. The canvas feature to help detail the selected idea received the highest evaluation score (4.68/5) (Table 8) compared to other features: “*The canvas adequately captured value proposition for the innovation and a benefit matrix*” (PC4). However, some sections included in the canvas could not be completed during the allocated time: “*We were unable to exhaust our discussions for each section*” (PC5). Furthermore, an additional template for the problem statement could be introduced to support concept descriptions.

Table 8. Quantitative evaluation of the features of the energy innovation canvas.

Feature Evaluated	Question	Score (out of 5)
	Completeness To what extent are the contents of the canvas complete (i.e., sections and corresponding questions)?	4.67
	Usability To what extent is the canvas easy to read and use (in terms of layout/colours/shapes etc.)?	4.56
Effectiveness		To what extent is the canvas helpful to describe the selected idea?
	To what extent is the canvas helpful to detail the selected idea describing each section?	4.68

4.1.3. Ideas Developed and Detailed during the Workshop

To triangulate with the findings from the observations of participants and the evaluation questionnaire, we also analysed the ideas recorded by each group on the idea generation diagrams. This enabled us to evaluate the outcomes that the toolkit helped to produce. We aimed at understanding which household energy issues were selected by the participants and the amount, relevance and originality of the developed and detailed ideas.

Each of the participating groups recorded between 18 and 45 ideas in one hour. Each group consisted of between four and six participants, meaning that each participant developed between 3 and 11 ideas. Prior to the idea generation session, the facilitators introduced the most common brainstorming principles and reminded the participants to record all ideas on Post-It notes. However, the participants often forgot to write down the ideas they shared verbally within the group, especially if they engaged in energetic discussion.

The participants developed ideas addressing three household energy issues they selected at the beginning of the workshop. Eleven different issues were selected by the participants out of the seventeen included in the toolkit, while four of them were selected twice. The participants selected issues from all six categories: accessibility (one issue); affordability (two issues); reliability (two issues); health and safety (three issues); income generation (two issues); social culture (one issue). Therefore, the ideas developed by the participants suggested energy solutions addressing a great range of energy-related issues in informal urban settlements.

The GENS codesign toolkit was developed to combine gender, energy and informal urban settlements. Therefore, we looked at whether and how the recorded ideas included all three elements. Most of the recorded ideas included the energy aspect and focused on low-income urban areas, e.g., *“Community kitty to maintain and service the street lighting, facilitated by community leader living in the area”* (group 3) and *“Smart systems to track illegal connections”* (group 5). In terms of gender inclusion, there were some ideas recorded that included the terms “women”, “men”, and “gender”, e.g., *“Role reversals. Fun ways to feel what it is like to be the opposite gender”* (group 4) and *“Awareness on how to create innovations using waste collected from the community. Involve youth and women”* (group 3). Several ideas included youth and communities, which referred to both genders: *“Training/sensitisation/awareness on how to create innovations using waste collected from the community. Involve youth and women”* (group 3). Even though gender was not specified in most of the ideas recorded on Post-It notes, group discussions and presentations included gender considerations. During the idea detailing stage, the energy innovation canvas encouraged participants to consider both genders, energy and informal urban settlements, and thus, the final detailed ideas sufficiently combined all three elements.

In terms of creativity and originality, the ideas ranged from generic: *“Energy efficient appliances”* (group 2), to elaborated and context-specific: *“Feasibility study for wind power to generate electricity to power outdoor lighting (Kosovo is located on a hill with potential for wind power generation)”* (group 3). Group 4, which addressed a communal entertainment facility challenge and included a design expert, developed particularly original ideas that did not repeat any information included in the toolkit: *“Self-defence classes for women-Kenya Karate Grannies”*, *“Mural/artwork for education on the electrical safety”* and *“Recruitment events/contests for sharing skills”* to name a few. In fact, the expertise of group members was reflected in the recorded ideas. Group 5, which also focused on a communal entertainment facility and included a policymaker, developed technical, cost and regulations-oriented ideas: *“Different billing schemes based on income level”*, *“Set standards for imports manufacturing of energy devices”* and *“Government to: formulate policy to provide incentives to enterprises to lower cost of energy devices”*.

5. Discussion

The first empirical application of the GENS codesign toolkit helped to identify its strengths, weaknesses, opportunities and threats. In this section, we reflect on the outcomes of the workshop and discuss future work.

5.1. Strengths of the GENS Codesign Toolkit and the Codesign Process

The high scores given in the toolkit's evaluation questionnaire (no less than 4.24/5 for a single feature) showed that the workshop participants enjoyed using the toolkit and considered it a successful instrument. The amount of data collected by the GENS researchers (through literature reviews, interviews with companies and ethnographic fieldwork) and included in the toolkit was found to be useful and appreciated by the users. Persona stories were found to be particularly engaging and educational. Those stakeholders who are responsible for energy provision constantly seek for better understanding of low-income users, who are often difficult to access and get to know. Therefore, they demanded more persona stories that illustrate different contexts. In addition, case studies helped to stimulate creative idea generation. In terms of the layout, the toolkit's visual design was complimented by the participants.

Active participant engagement, which is critical for the success of codesign, was observed during the workshop. The toolkit, and especially both types of cards, stimulated lively discussions and successfully supported idea generation. Context-specific data collection during the workshop encouraged conversations between different stakeholders and involved Mathare community members who helped others understand the Mathare energy scene. As a result, the majority of generated ideas was context-specific and targeted low-income urban communities. The variety of household energy issues selected by the participants to address showed that the selection of issues provided in the toolkit was sufficient and useful. Each group, which comprised between four and six members, generated between 18 and 45 ideas in one hour, demonstrating the toolkit's ability to support idea-brainstorming sessions. Some of the developed ideas were either gender-focused or indirectly considered both genders. The final idea-detailing activity ensured that gender considerations were incorporated into the final solution.

5.2. Weaknesses of the GENS Codesign Toolkit and the Codesign Process

The testing showed that the toolkit, and especially the introductory problem exploration diagram, could be more "gendered", i.e., include more roles of both genders and specify issues, needs and capabilities for different age groups of women and men. Furthermore, the sustainability potential of using the toolkit was not clear. The workshop participants highlighted the absence of Kenyan context-specific information, such as statistical analysis of energy use and preferences, local initiatives and images of real community members. Our aim was to create a toolkit applicable in different contexts. However, this requirement could be addressed by providing context-specific information prior to the workshop and including links to online databases and local case studies in the toolkit. It was observed that the information provided in the toolkit could be difficult to understand because of the amount of text and the English language, which was not native to most of the participants. The toolkit could potentially be less textual, more visual and even translated to local languages. In terms of the layout, the text size of all the toolkit's elements was too small, even for the A3-sized paper, making comprehension of the information challenging.

In terms of the codesign process, some participants experienced a lack of linkage between different stages, as the questions listed on the cards cannot be always directly applied to the variety of challenges selected by the users. In addition, each element of the toolkit was also lacking use guidelines written on them: it was not always clear where to start reading the provided information and how to use the templates and the energy innovation canvas. Moreover, there was a lack of support for "the most promising" ideas selection before the idea detailing exercise. These issues can be addressed by updating the contents of the toolkit or improving the workshop design and facilitation.

5.3. Opportunities for the GENS Codesign Toolkit and the Codesign Process

It emerged from our testing that the users considered it very important to obtain context-specific information. To a certain extent, this goes somewhat against our goal to develop a toolkit that is applicable in different contexts. A potential way to align these two

requirements would be to add a set of context-specific layers to the core elements of the toolkit. These layers would, for example, provide country-specific information (e.g., the current situation in terms of gender mainstreaming, specific gender issues and current best practices). There could also be layers for each of the different types of informal urban settlements (e.g., following the classification provided by Smit et al. [44]).

In terms of the format, the current version of the toolkit is physical (i.e., paper-based). As a result, its use in a codesign process can take place only in a face-to-face mode. To overcome this drawback, there is the opportunity to develop the toolkit into a digital form. This would provide a range of benefits: (1) it would allow for individual online use (e.g., a single practitioner), as well as group use (e.g., multiple people within the same company or representatives from different energy stakeholders); (2) it would allow participation from people from different geographical areas; (3) it would allow users to digitally save data inputted in the different sections of the toolkit and share this data with other users; (4) it would allow simultaneous and asynchronous use from different users; (5) it would allow for embedding links to external resources (e.g., scientific papers and best practices); (6) it would allow for much wider dissemination of the toolkit; and finally, (7) it would allow for updates/improvements of the toolkit to be easily disseminated.

5.4. Threats for the GENS Codesign Toolkit and the Codesign Process

A key threat is that the contents of the toolkit might become obsolete. For example, some of the gender issues addressed by the toolkit might become irrelevant in the future, and at the same time, new issues might emerge. In addition, user practices change over time and the ethnographic data embedded in the toolkit might not reflect the future reality. Furthermore, new best practices and gender mainstreaming strategies might emerge, making some of the content of the toolkit not up-to-date. A potential way to overcome this problem could be to provide content updates to toolkit users. As discussed in the previous section, this could be more effective if the toolkit is in a digital format (e.g., by allowing users to download upgrades or new versions). In order to speed up the updating process, another strategy could be to allow users to input/suggest new content or to enable them to become “content generators” and develop their version of the toolkit (in an open-source and copyleft ethos).

Another threat to the toolkit is that its use currently requires the presence of an experienced facilitator (more on this in the next section). This is potentially problematic for two reasons: first, it could limit the use of the tool; second, if the toolkit is used without a facilitator (or with an inexperienced facilitator), the outcomes might be of low quality and the experience of users might not be positive.

5.5. The importance of Facilitation

We observed that the workshop design and the facilitation of the codesign process played an integral role in its success. The workshop must start with introductions to background information to make sure all participants are familiar with the terminology, context-specific data, existing issues and best practices before starting the codesign activity. The introductory part must be followed by a detailed presentation of the toolkit. The GENS codesign toolkit consists of six different components, thus it is critical to provide sufficient use instructions and support its application process step-by-step, ideally showing it on a screen. Furthermore, it is important to present alternative ways of using each tool to allow some degree of flexibility. Experienced facilitators must be present during the whole workshop. Supportive facilitation can help to address a lack of participant engagement and increase the number of ideas recorded on Post-It notes. A gendered approach to the workshop dynamics can help to ensure more gender-inclusive outcomes. Each group must include female and male participants, ensuring that all of them can express their opinion and share ideas despite their gender. As a result, there can be a need to have more representatives from each role of the energy sector to ensure an expertise and gender balance. Finally, the multistakeholder workshop can take more than 5 h 30 min to

sufficiently complete the proposed codesign process. Each participating group could be provided with more copies of each tool.

5.6. Improvements to the Toolkit

The first evaluation round of the GENS codesign toolkit is complete. The codesign workshop helped to decide which changes and improvements are going to be implemented in the next version of the GENS codesign toolkit, including the facilitation and workshop design for the toolkit's use guidelines (Table 9).

The updated version will be ready to be used in the GENS Living Labs and other multistakeholder codesign activities. In fact, during the workshop, representatives from two private companies expressed their interest in applying the toolkit in their companies' work. Therefore, the new version of the toolkit can also be used by a single stakeholder independently. It will potentially be developed in a digital format that is enriched with links to additional data and information relevant to the context of the application.

Table 9. Insights gathered from the codesign workshop with suggestions for implementation in the next version of the GENS codesign toolkit.



Toolkit's Elements	What Worked?	What Suggestions Emerged from the Workshop?	Will the Suggestion Be Included in the Next Version of the Toolkit?
All elements of the GENS codesign toolkit 	<ul style="list-style-type: none"> • Successfully integrates gender. • Supports energetic dialogue between the users. • Adaptable: the application can be modified by the users. • Supports data collection for a better understanding of the context. • Supports idea generation considering gender, energy and informal settlement aspects. • Supports generation of ideas, ranging from generic to original and elaborated. • Can be applied by private companies individually. 	Include use guidelines in each of the tools.	Yes. Brief guidelines will be included: descriptions of each block of information and reading order of each of the tools.
		Increase the size of the prints.	Yes. The prints will be increased by one format size (i.e., from A3 to A2, etc.).
		Increase text size.	Yes. The text size will be increased as a result of the increased size of the prints.
		Translate the tools to local languages.	No. The English version was understood by all workshop participants. Images of case studies helped to improve comprehension.
Problem exploration diagram 	<ul style="list-style-type: none"> • Complete regarding content. • User-friendly layout. • Distinguishable colours. • Supports selection of diverse energy-related issues to be addressed. 	Include local context-specific information with statistics, case studies and initiatives for each of the energy issues.	No. The diagram is an introductory tool that summarises the information included in the toolkit. More details are provided in the energy issue cards. The toolkit is made to be used in different contexts; thus, the included information includes different contexts. A digital version of the toolkit could include links to online databases that store relevant information from different contexts (e.g., UN Stats information on SDGs).
		Include sustainability implications.	No. The potential sustainability implications of using the toolkit will be summarised in the toolkit's use guidelines, together with other introductory material.

Table 9. Cont.





Toolkit's Elements	What Worked?	What Suggestions Emerged from the Workshop?	Will the Suggestion Be Included in the Next Version of the Toolkit?
<p>Energy issues cards and additional data collection template</p> 	<ul style="list-style-type: none"> • Complete regarding content. • Comprehensible language. • Case studies successfully complement the contents of the cards. • Case studies and idea generation questions successfully support idea generation. 	<p>Simplify the language.</p> <hr/> <p>Describe case studies by specifying implications for women and men.</p> <hr/> <p>Provide more information on roles of each gender.</p> <hr/> <p>Provide more context-specific case studies.</p> <hr/> <p>Provide the aspects of government involvement in the energy sector.</p> <hr/> <p>Reduce information in the cards.</p> <hr/> <p>Combine the energy issue card with the additional data collection template.</p>	<p>Yes. Each sentence will be revised and potentially simplified to improve comprehension.</p> <hr/> <p>Yes. More information on how the case studies address the needs of women and men will be included.</p> <hr/> <p>Yes. More information on gender roles will be included in the description of causes and the questions for idea generation.</p> <hr/> <p>No. The toolkit is made to be used in different contexts; thus, the included information addresses different contexts.</p> <hr/> <p>No. Government positions are described among the causes of some of the issues. However, government involvement varies from country to country, while the toolkit aims to include context-neutral information.</p> <hr/> <p>No. The aim of the energy issue cards is to provide in-depth information on the energy issues.</p> <hr/> <p>No. Being a separate tool, the additional data collection template can be used with the energy end-use cards too.</p>
<p>Energy end-use cards and additional data collection template</p> 	<ul style="list-style-type: none"> • Complete regarding content. • Distinguishable colours. • Case studies successfully complement the contents of the cards. • Supports gender inclusion during group discussions and presentations of generated ideas. • Named as “the best part of the toolkit” by the users. 	<p>Simplify the language.</p> <hr/> <p>Include more gender considerations in the idea generation questions.</p> <hr/> <p>Include context-specific case studies.</p>	<p>Yes. Each sentence will be revised and potentially simplified to improve comprehension.</p> <hr/> <p>Yes. More considerations on gender roles will be included in the questions for idea generation.</p> <hr/> <p>No. The toolkit is made to be used in different contexts; thus, the included case studies will remain diverse.</p>
<p>Idea generation diagram</p> 	<ul style="list-style-type: none"> • Complete regarding content. • Supports the categorisation of generated ideas. 	<p>Provide an explanation of how to select the idea(s) for further detailing.</p> <hr/> <p>Add colours.</p> <hr/> <p>Include identification of the actor network as the next step.</p>	<p>Yes. Explanation of how to select “the most promising idea” will be included.</p> <hr/> <p>No. The six different colours used in the toolkit are associated with different categories of household energy issues. Same or new colours will not be included in the diagram to avoid confusion.</p> <hr/> <p>No. The actor network is included in the energy innovation canvas, which is made to be applied in the next step.</p>

Table 9. Cont.

Toolkit's Elements	What Worked?	What Suggestions Emerged from the Workshop?	Will the Suggestion Be Included in the Next Version of the Toolkit?
Energy innovation canvas 	<ul style="list-style-type: none"> • Complete regarding content. • User-friendly layout. • Effectively supports idea detailing. 	Include sustainability and social issues.	Yes. Implications of environmental, social, and economic sustainability will be included in the <i>Outcomes</i> section.
		Make the canvas customisable depending on the idea.	No. However, use guidelines will specify that the canvas can be filled in any order, depending on specific ideas and that some sections can be left blank.
		Reduce repetitive sections (e.g., customer section is not always relevant)	
		Number a suggested order.	
		Add colours.	No. The six different colours used in the toolkit are associated with different categories of household energy issues. Same or new colours will not be included in the diagram to avoid confusion.
Facilitation and workshop design: GENS codesign toolkit's use guidelines	<ul style="list-style-type: none"> • The introductory presentations gave background information on gender, energy and informal urban settlements and helped with understanding the context. • The brainstorming principles were used during the idea generation. • Community members were crucial participants since they helped other stakeholders to better understand the energy context and informed the selection of issues to address. 	Make an additional template for the problem statement.	No. However, the space dedicated to idea descriptions will be enlarged.
		An internal facilitator could join each group to facilitate participant engagement.	Yes. However, an internal facilitator must not influence the selection of energy issues, suggest their own ideas or get involved in idea detailing.
		Remind people to record ideas on the idea generation diagram.	
		Ensure equal representation of stakeholders from different sectors.	Yes. An equal number of women and men from public and private sectors must be involved in the codesign activity.
		Allocate more time for each stage of the codesign process.	Yes. Problem exploration, idea generation and idea detailing stages must be prolonged by at least 20 min each.
		Ensure all participants, regardless of gender, present their ideas.	Yes. A facilitator must include gender considerations while preparing for the workshop and during its implementation.
		Provide more copies per group of each tool.	Yes. At least two copies of each tool must be provided for each group.

6. Conclusions

In this paper, we present the first version of the GENS codesign toolkit that was made to support the design of energy innovations for informal urban settlements considering different issues, needs and capabilities of female and male energy users. The toolkit consists of six tools combined into our proposed codesign process. We tested the toolkit during a one-day codesign workshop in Nairobi, Kenya. The workshop simulated the activity that would potentially be implemented in the GENS Living Lab and was attended by representatives from private energy companies, Mathare informal settlement community members, energy researchers and a policymaker.

The toolkit expands know-how on the gender-energy nexus in urban areas and supports three Sustainable Development Goals (SDGs) [52]. In relation to SDG 5 'Gender equality' and SDG 7 'Affordable and clean energy', the toolkit supports energy companies in becoming more aware of gender-related energy issues and in developing solutions that can ensure energy security and, at the same time, address those issues. In addition, since the toolkit is specifically focused on informal urban settlements, it also supports *SDG 11: Sustainable cities and communities*, with a particular focus on SDG 11.1 related to access to basic services and upgrade of slums.

By evaluating the toolkit's completeness, usability and effectiveness, we identified that it successfully helped its users to learn about energy use in informal urban settlements and generate original ideas for energy innovations. We observed that the toolkit facilitated the dialogue and knowledge exchange between different stakeholders, which is critical

for a fruitful codesign activity. The workshop also enabled us to identify the limitations of the toolkit, such as a lack of use guidelines and drawbacks of the layout, which are to be addressed in the next version of the toolkit. The testing provided a complete list of changes that need to be implemented in the second version of the toolkit.

In terms of value to the research community, this paper addresses the identified research gap by putting forwards a design toolkit that uniquely focuses on mainstreaming gender in energy projects, with an emphasis on idea generation and informal urban settlements. Researchers working on the gender–energy nexus can build upon these results, for example, by adopting the toolkit in their own projects or by identifying improvements to be made. The paper also provides insights on the methodological aspects to be taken into account to thoroughly test design toolkits. In terms of value to practice, the toolkit can provide energy companies, organisations and practitioners with a novel approach to integrating gender mainstreaming in energy projects for informal urban settlements. This toolkit specifically focuses on helping its users to identify gender-related energy issues and to facilitate idea generation processes. The final revised version of the GENS codesign toolkit must be seen as complementary to the current tools, handbooks and manuals on mainstreaming gender in energy projects.

Regarding the limitations of this research, two main aspects can be highlighted. First, the toolkit was tested only on one occasion. Although we were able to collect a rich set of data from different types of energy stakeholders, additional testing must be performed to strengthen the validation of the toolkit. Second, the toolkit was tested only with stakeholders from the same geographical area. It can therefore be questioned to what extent the results would change if the toolkit was tested in a different location. In order to address these limitations, we are planning to carry out additional testing in Groenheuwel (Paarl, South Africa) within the other GENS Living Lab. In addition, we are also planning to test the toolkit with individual companies/organisations to gather data on how this mode of use compares with use of the toolkit within a multi-stakeholder codesign workshop.

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Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: Not applicable.

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Appendix A

Table A1. A list of gender–energy nexus supports analysed to define established practices of gender mainstreaming in energy projects.

Reference	Type	Context	Link
Morris, E., Greene, J. and Healey, V.M. Blueprint Guide for Creating Gender-Sensitive Energy Policies. United States: N. p., 2019.	Guidebook	ECOWAS countries. Rural and urban.	https://www.nrel.gov/docs/fy19osti/73927.pdf (accessed on 20 May 2022)
ADB. Gender-Inclusive Approaches in the Energy Sector. Asian Development Bank, 2018.	Tipsheet	Low-income Asia. Rural.	https://www.adb.org/documents/tip-sheet-gender-inclusive-approaches-energy (accessed on 20 February 2022)
Nelson, S. and Kuriakose, A.T. Gender and Renewable Energy: Entry points for women’s livelihoods and employment. Climate Investment Funds, 2017.	Guidebook	Developing countries worldwide. Rural and urban.	https://www.climateinvestmentfunds.org/sites/cif_enc/files/gender_and_re_digital.pdf (accessed on 20 February 2022)
DOE. Gender Toolkit for the Energy Sector. Manila, Philippines, 2016.	Toolkit	The Philippines. Rural.	https://www.apec.org/docs/default-source/Publications/2017/5/Guidelines-to-Develop-Energy-Resiliency-in-APEC-Off-Grid-Areas/TOC/Annex-8-Philippines-DOE-Gender-Toolkit.pdf (accessed on 20 February 2022)
Hjorth, H., Vyzaki, M. and Bergman, M. Gender Mainstreaming in District Heating Projects in the Commonwealth of Independent States: A Toolkit. CIF, 2016	Toolkit	Ukraine and Kazakhstan.	https://www.climateinvestmentfunds.org/sites/default/files/gender_mainstreaming_in_district_heating_projects_english.pdf (accessed on 20 February 2022)
Smith, G. and Shankar, A. Empowered Entrepreneur Training Handbook, Washington DC: Global Alliance for Clean Cookstoves, 2015.	Training manual	Developing countries worldwide. Rural and urban.	https://cleancooking.org/wp-content/uploads/2021/07/342-1.pdf (accessed on 20 February 2022)
O’Neil, D.; Renzy, D.; McDermott, A. and Atanassova, A. Building a Safer World: Toolkit for Integrating GBV Prevention and Response into USAID Energy and Infrastructure Projects. Rockville, MD: USAID’s Advancing the Agenda of Gender Equality (ADVANTAGE), Task Order 3, 2015.	Guidebook	Developing countries worldwide. Urban.	https://www.usaid.gov/documents/1865/building-safer-world-toolkit-integrating-gbv-prevention-and-response (accessed on 20 February 2022)
ESMAP. Gender Equality and Energy: Tools and Guidance for Integrating Gender Issues into the Energy Sector. WBG, 2015.	Guidebook	Developing countries worldwide.	https://www.esmap.org/sites/esmap.org/files/DocumentLibrary/Gender_Energy_M06.pdf (accessed on 20 February 2022)
SPC. Toolkit to Mainstream Gender into Energy & Climate Change Community Based Adaptation Projects in the Pacific, 2013.	Toolkit	The Pacific. Rural.	https://gendercc.net/fileadmin/inhalte/dokumente/4_Our_Work/past_projects/Pacific_Islands/Toolkit_to_Mainstream_Gender_into_Energy___Climate_Change_Community_Based_Adaptation_Projects_in_the_Pacific.pdf (accessed on 20 February 2022)
SPC. Gender Mainstreaming in Energy Projects in the Pacific, 2014	Training manual	The Pacific. Rural.	https://gendercc.net/fileadmin/inhalte/dokumente/4_Our_Work/past_projects/Pacific_Islands/Training_Manual_Gender_Mainstreaming_in_Energy_Projects_in_the_Pacific.pdf (accessed on 20 February 2022)

Table A1. Cont.

Reference	Type	Context	Link
UNIDO. Guide on gender mainstreaming: Energy and climate change projects. Vienna, 2014	Guidebook	Developing countries worldwide. Rural and urban.	https://www.unido.org/sites/default/files/2015-01/Guide_on_Gender_Mainstreaming_ECC_0.pdf (accessed on 20 February 2022)
Rojas, A. and Siles, J. Guide on Gender and Energy for Trainers and Managers of Public Policies and Projects, ENERGIA, OLADE and UICN, 2015	Training manual	Latin America. Rural and urban.	https://biblioteca.olade.org/opac-tmpl/Documentos/old0370.pdf (accessed on 20 February 2022)
Dutta, S. Gender Briefing Notes: Supporting active inclusion of women in energy and development projects. EUEI PDF, 2013	Briefing notes	Developing countries worldwide. Rural.	https://www.wame2030.org/files/catalogue/2016/12/gender_briefing-notes_1.pdf (accessed on 20 February 2022)
World Bank. Integrating Gender Considerations into Energy Operations. ESMAP knowledge series 014/13. Washington, DC. 2013.	Briefing notes	Africa. Rural.	https://openknowledge.worldbank.org/handle/10986/17479 (accessed on 20 February 2022)
CCA. Scaling Adoption of Clean Cooking Solutions through Women's Empowerment. Global Alliance for Clean Cookstoves, 2013.	Guidebook	Developing countries worldwide. Rural and urban.	https://www.empowerwomen.org/en/resources/documents/2013/11/scaling-adoption-of-clean-cooking-solutions-through-womens-empowerment-a-resource-guide?lang=en (accessed on 20 February 2022)
ADB. Gender Tool Kit: Energy. Going Beyond the Meter. Philippines, 2012	Guidebook	Asia. Rural.	https://www.adb.org/sites/default/files/institutional-document/33650/files/gender-toolkit-energy.pdf (accessed on 20 February 2022)
ENERGIA. Mainstreaming gender in the energy sector: Training manual. 2012	Training manual	Mozambique and Liberia. Rural.	https://www.energia.org/assets/2016/09/Mozambique-Manual-Mainstreaming-Gender-in-the-Energy-Sector-Training-Manual-final.pdf (accessed on 20 February 2022)
ENERGIA. Mainstreaming Gender in Energy Projects: A Practical Handbook. Practical action, 2011.	Handbook	Asia and Africa. Rural.	https://ppp.worldbank.org/public-private-partnership/sites/ppp.worldbank.org/files/documents/Energia_Mainstreaming_gender_in_energy_projects_A_practical_Handbook.pdf (accessed on 20 February 2022)
UNDP. Gender Mainstreaming: a Key Driver of Development in Environment & Energy. Energy & Environment Practice: Gender Mainstreaming Guidance Series, New York, 2007	Training manual	Developing countries worldwide. Rural.	https://www.undp.org/content/dam/undp/library/Environment%20and%20Energy/Sustainable%20Energy/Gender_Mainstreaming_Training_Manual_2007.pdf (accessed on 20 February 2022)
UNDP. Gender and Energy for Sustainable Development: A Toolkit and Resource Guide. 2004	Toolkit and guidebook	Developing countries worldwide. Rural.	https://www.undp.org/publications/energy-and-gender-sustainable-development-toolkit-and-resource-guide (accessed on 20 February 2022)

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