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Kumar Ajesh, Wolff Annika, Naqvi Bilal

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Co-creating Community-level Indicators: Involving Communities in the Digitalization of Energy for Empowering Energy Citizenship

A. Kumar, A. Wolff, B. Naqvi
Software Engineering, LENS, LUT University, Lappeenranta, Finland
ajesh.kumar@lut.fi

***Abstract* - Energy citizenship refers to the participation of individuals or communities in activities that support the green transition. Whilst individuals may set their own targets for greener living, several initiatives are also being designed and encouraged at the city and regional level, e.g., renewable energy cooperatives and increased electric mobility. Enacting change is a long-term process, requiring monitoring and possible adaptation along the way and initiatives may fail without buy-in from the local community. Digitalization of energy and energy-related systems can produce large quantities of data that the has potential for helping to achieve green targets and monitor progress against them. However, when the initiatives and the data collected to monitor them are defined in a purely top-down manner it risks missing the priorities of local communities, which may affect willingness to participate. This paper explores a co-creation process through which local communities define transition goals and ways to monitor the progress that reflects their own priorities in the form of community-level level indicators (CLIs), as well as the metrics needed to track them. It will explore a common template for defining CLIs and describe their use within several green initiatives across Europe.**

Keywords - digitalization, energy systems, community-level indicators, empowerment, society 5x

I. INTRODUCTION

Energy is a vital resource for communities, and its availability and cost can greatly affect a community's economic and social well-being [1]. Perceptions of energy can vary greatly among different communities with some placing a greater emphasis on environmental concerns and others prioritizing economic development [1]. Additionally, low-income and marginalized communities often have limited access to energy services and may be disproportionately impacted by energy-related issues [2]. It is therefore vital that policymakers and energy providers consider different communities' diverse perspectives and needs when developing and implementing energy policies and programs.

When it comes to the inclusion of multiple perspectives in the design and development of new policies and programs, the co-design approach is often utilized [3]. Co-design is a participatory design approach that involves the active involvement of stakeholders, including community members, in the design process of a project or initiative. It has also been found to be effective in community settings for creating sustainable and equitable energy systems and energy practices [3].

Furthermore, for global goals like decarbonization and green transition where multiple communities and stakeholders get involved, there is a need for metrics that enable policymakers, planners, and community leaders to make informed decisions based on historical and current trends, as well as predictions for future outcomes. A Community-Level Indicator (CLI), also known as a community indicator is a metric that enables multiple stakeholders to make informed decisions and predictions. CLIs are extensively employed in various fields of study, including health, sustainability, environment, climate, energy, and urban planning. The utilization of CLI can provide insights into the performance of policy implementation across social, economic, and environmental dimensions [3]. By combining indicators, they generate a picture of what is happening in a community and can provide information about past trends, current realities, and future directions to support decision-making.

In the field of energy, Community Level Indicators (CLIs) are crucial for promoting energy sustainability and striving toward an equitable transition. These indicators encompass a range of factors, such as access to electricity, availability of clean fuels and technology for cooking and heating, and the proportion of renewable energy in use [4].

This paper discusses the utilization of the co-design approach within the context of energy communities and outlines the steps required to conduct co-design workshops across different communities, either online or face-to-face. Furthermore, the paper presents the outcomes of conducting co-design workshops within four different energy communities in Europe. The workshops were aimed at developing Community Level Indicators (CLIs) that reveal how each community prefers to measure their progress towards objectives and decarbonization targets of local initiatives towards a green transition.

The remainder of the paper is organized as follows. Section II presents the background of the topic. Section III presents the details of developing the co-design framework, Section IV presents the results. Section V presents the discussion, and Section VI concludes the paper.

II. BACKGROUND

This section presents details about (1) community-level indicators (CLI), and (2) the co-design approach. The details are presented in the following subsequent sub-sections.

A. Community Level Indicators

A distinguishing characteristic of CLI is that they are derived from community-level information rather than individual-level data, e.g., indicators focusing on aspects such as the presence of no-smoking areas in restaurants or smoking cessation clinics within a local community to measure progress on improving the health of a community, rather than focusing on individual smoking behaviors and whether they go up or down.

In the existing literature [5], the authors have outlined five main applications for community or neighborhood indicators including, (1) s*ituation Analysis*: analyzing whether situations in a community are getting better or worse., (2) p*olicy analysis and planning*: providing evidence for formulating policy., (3) p*erformance management and evaluation*: monitoring the performance of an intervention., (4) *education and engagement*: empowering communities to act on problems, by presenting data (e.g., crime statistics) in ways that are easy to understand and interpret., and (5) n*eighborhood research*: identifying patterns of cause and effect, such as the effect of neighborhood conditions on individual outcomes.

In the existing literature [6], the authors created a framework for monitoring the sustainability of local fisheries using Community Level Indicators, which combined expert and local knowledge through focus groups. The indicators were categorized based on various aspects of sustainability that were relevant to the local context, including community, ecological, institutional, and socio-economic factors. The authors [6] suggest that a community-level indicator (CLI) approach can incorporate diverse expertise through a combination of top-down and bottom-up processes, as seen in their own case study.

In the existing literature [7], the author identified two approaches for developing CLIs, (1) outcome-oriented, and (2) context-oriented. The former focuses on finding differences in outcomes within the community area, while the latter focuses on the community as an environment that may affect result in positive or negative ways, which in turn may reflect in higher or lower rates of expected outcomes.

Furthermore, Participatory Sensing (PS) data can be useful for individuals with limited experience in data analysis by co-creating CLIs through participatory workshops [8]. Participatory Sensing enables communities to gather data to support their cause, such as recording noise pollution levels to lobby local authorities [8]. In [8] researchers engaged local communities in workshops to identify CLIs that were meaningful. Moreover, in [8], it was found that the co-creation of community-level indicators increased the awareness of the problem and the need to find solutions. This is consistent with the existing work [5] perspective, which suggests that indicators can empower communities to act on issues of interest, particularly when presented in an easily understandable format for a broad audience.

To summarize, the following aspects are the key to be considered in the development of CLIs:

- Familiarization with the problem
- Collaborative goal setting.
- Mapping goals to indicators.

B. Co-design Methodology

The term co-design encompasses different participatory methods that aim to engage users or customers in a collaborative and innovative design process. Co-design offers several benefits, including the ability to produce outcomes that are better aligned with the needs of users or customers, making them more likely to accept and adopt the results of the process [9].

The co-design process involves iteratively refining initially ambiguous ideas. In [10] researchers identified four common phases of co-design, (1) starting with pre-design activities to prepare participants for the process, (2) the generative phase for exploring the design space and producing ideas using tailored tools and methods, (3) evaluative phase to assess the outcomes, and (4) post-design phase for research to determine how well the design meets the needs of people. The generative phase typically employs tools and methods based on making, telling, enacting, or combining these approaches. Making involves creative acts, supported by probes, toolkits, or prototypes. Telling is more dialogue-based, with techniques like World Café, fishbowl, diaries, or prompts. Enacting involves demonstrating through action, such as body storming, where a story is acted out to illustrate a particular design.

To summarize, the key aspects to consider while planning and executing co-design are:

- The four stages can be employed to structure the co-design of CLIs.
- When selecting activities for the generative phase of the co-design, it is advisable to concentrate on making and telling. Enacting does not correspond to the need to support both online and offline co-design, nor is it suitable for the design task.

III. DEVELOPING THE CO-DESIGN PROTOCOL

By drawing from various domain-specific literature we proposed a co-design protocol that includes a 4-stage setup such as pre-design, generative, evaluative, and post-design stages. Table I outlines the stages which can be used for co-designing community-level indicators (CLIs) and furthermore these co-design approaches were implemented for identifying CLIs. The co-design stages provide suggestions for actions or tasks that may be included and describe the rationale considerations and the involvement of stakeholders at each stage. These stages are discussed below along with the type of stakeholders or participants.

TABLE I. CO-DESIGN STAGES FOR IDENTIFYING CLI ACROSS ENERGY COMMUNITIES

Co-design stage	Actions	Description	Task Participants
Pre-design	Identify project goals	Identify the purpose of the CLIs, especially so that these goals can be communicated clearly as part of the co-design process [5]. Define the scope of involvement in utilizing CLIs beyond their ideation, taking into consideration factors such as the availability of data, requirements for specialist tools, and similar.	Researchers
	Conduct a literature review	A literature review allows researchers to produce an initial set of indicators to 'seed' the co-design and provide informative examples. This is common literature and not related to any individual energy community. These CLIs may have an outcome or a contextual orientation[7].	Researchers
	Filter CLIs for local context	Conduct an initial filtering of CLIs to reduce the CLIs from the literature to a small set relevant to the case study.	Researchers
	Identify key stakeholders	The stakeholders represented in the co-design activity may play a significant role in deciding the relevant CLIs.It is thus important to consider how to effectively combine top-down and bottom-up processes to maximize the benefits of community involvement. [6].	Researchers
	Define a recruitment strategy	Define a recruitment strategy for attracting identified stakeholders to participate in the workshop(s). The gains from participation should be identified and communicated.	Researchers, technologists, problem-owners, general public
	Planning for codesign workshop(s)	Select a co-design methodology to follow, e.g., Dialogue Lab, World Café, or another. Select appropriate tools to facilitate ideation within the chosen co-design process, considering activities may be either online or offline – for example making or telling but not enacting [10]. Define how space is set up [11], and in these days, especially whether it will be online, face-to-face, hybrid/synchronous, or asynchronous. Ensure adherence to ethical principles and use of consent forms as well as data management. Identification of materials (including technologies and software) needed to support co-design activities.	Researchers, technologists, problem-owners, general public
Generative	Introduction and familiarisation with the problem	Utilize a subset of CLIs as examples of indicators that are more relevant to the community. In this step, CLIs are explained in detail with examples to show how the CLI is used to measure some community parameters and data required	Researchers, technologists, problem-owners, general public
	Defining the community boundary	Based on geography, or some other definition, boundaries may be defined to mark the scope of the co-design activity[7]	Researchers, technologists, problem-owners, general public
	Collaborative community goal setting	Setting up community goals collaboratively allows participants to identify common goals as well as help reach a consensus on which goals to prioritize and the expected timeline.	Researchers, technologists, problem-owners, general public
	Ideating new indicators within the framing of goals and CLI dimensions	Whether to define thresholds, create CLI repositories, levels of evaluation, etc. How to overcome data literacy, technical, political, and privacy issues? Or problems with 'small' data? [13]. How will CLIs be measured?	Researchers, technologists, problem-owners, general public
Evaluative	Evaluating CLIs and making the final selection	Evaluate CLIs according to aspects, such as relevance, completeness, availability, measurability, reliability, familiarity, nonredundancy, and independence.	Researchers, technologists, problem-owners, general public
	Closing activities	E.g., 'harvest' or sharing the final outputs and capturing the results, debriefing, and filling questionnaires.	Researchers, technologists, problem-owners, general public
Post-Design	Utilizing CLIs within communities as part of defining CTPs	Identifying the availability of required data. Analysing available data in the context of the specific goal. Longitudinal tracking of co-design participants to understand the effects of participation?	Researchers, technologists, problem-owners, general public

As depicted in Table I, during the pre-design stage project goals are identified. The literature review should be conducted to produce an initial set of indicators to 'seed' the co-design and provide informative examples. Once CLIs are identified they should be filtered for local context the next steps are to identify key stakeholders who could take part in the workshop activity and invite the potential participants explaining the goal for the workshop along

with dates, duration, and the location that has been identified for the workshop. Once workshop participants are recruited the planning for codesign workshop(s) must be created.

In the generative stage, workshops are conducted by first giving an introduction about the community and participants are made to familiarize themselves with the problem. Moreover, defining the community boundary which could be based on geography or other factors could help determine the scope of the workshop and CLI generated. In the next step, participants may indulge in collaborative goal setting for the community and ideating new indicators within the framing of goals and CLI dimensions.

In the evaluation stage, CLIs are evaluated according to aspects, such as relevance, completeness, availability, measurability, reliability, familiarity, non-redundancy, and independence into a final list. In closing activities, workshop facilitators share the final outputs and the results, debrief the participants, and may ask them to fill out questionnaires.

In the post-design stage, the generated CLIs can be utilized to map transition pathways to achieve the sustainability goals of the community.

The materials and equipment that could facilitate the face-to-face co-design process may include consent forms, refreshments, a large screen for a group presentation, A3-sized sheets, whiteboards or flip charts, tables and chairs, sticky notes, medium-sized markers and pencils, pin boards or thick cardboard, A5-sized paper or card, and glue.

IV. Results

As stated in section III, the co-design protocol was executed by involving four different energy communities, energy researchers, policymakers, energy executives, and the general public. The workshops aimed to share the needs and experiences of the community on the topic of energy, environment, and climate and to reflect together on what possible actions can be put in place to achieve the decarbonization of their neighborhoods and cities.

The recruitment strategy [14] was incorporated to recruit participants for the workshops. To ensure the successful implementation of CLI workshops, effective recruitment, and involvement of key stakeholders are crucial, and gatekeepers play an important role in this process. Gatekeepers act as coordinators of information between different groups of stakeholders and represent individuals who are heard within their contexts and have easier access to different parties, thus facilitating communication and bridging gaps.

The workshop aimed to identify the manifestations of energy citizenship at various levels such as local, regional, and national levels. The workshop enabled participants to explore various aspects, such as how individuals can reduce energy consumption in their daily lives, how the community can contribute to reducing energy consumption in the neighborhood, and how the community can collectively take action to have a global impact. This allowed participants to gain a better understanding of energy consumption, generation, and energy business as well as local energy policies. This increased the overall understanding of the topic, guided by facilitators, and allowed participants to explore different goals types like short-term, mid-term, and long-term and listed different actions that could lead to the achievement of goals.

The various activities carried out during the workshops led to the discovery of several community-level indicators (CLIs) presented in Table II. Though there were many indicators that were co-created, not all of them were relevant or measurable. These indicators can also be classified into different types environmental, technical, economic, and social. The in-depth discussions during the workshops resulted in well-refined CLIs. All the CLIs explored are outside the scope of this paper.

V. Discussion

Based on the findings, it can be concluded that the co-design approach is effective in producing a diverse range of community-level indicators (CLIs) that addressed various goals and belonged to different categories, including environmental, social, technical, and economic. The workshop plan template was also useful for organizing the workshops into manageable tasks and creating a plan.

In the co-creation of community-level indicators, organizing a workshop can be challenging, especially in situations like a pandemic. Therefore, workshops need to incorporate mitigation strategies and be adaptable. A workshop protocol was found to be useful and adaptable, as both face-to-face and online workshops were able to successfully follow it and tailor it to their own needs. The results showed that the CLIs identified belonged to different categories such as Environmental, Technical, Economic, and Social, broadly. However, a particular workshop may have defined its own set of categories for the indicators.

The next step after listing the community-level indicators is to evaluate them based on specific questions, such as how to measure the indicator, where is the data, and whether new data sources require investment. By selecting some of the proposed indicators, it is possible to analyze the potential for data collection to track improvements in energy citizenship in the area. Data can be collected from various sources, including technical and non-technical data

TABLE II LIST OF CLI CO-DESIGNED DURING WORKSHOPS

Communities	Description	Indicator type	Indicators
Bologna, Italy	The mixed-use district in Bologna comprises two neighborhoods,	Environmental	Percentage of municipal budget directed to environmental-themed workshops.

Communities	Description	Indicator type	Indicators
	namely Pilastro (residential) and Roveri (industrial). Pilastro being planned as a self-sufficient neighborhood with mixed services and activities, it has become a mono-functional residential area with socio-economic challenges such as energy poverty. In contrast, Roveri is home to diverse companies across multiple sectors and is actively involved in establishing the first energy community in the city, leveraging the presence of local industrial partners with large photovoltaic plants.		The number of new energy/environmental-themed associations.
		Technical	The number of people installing Smart Meters or similar devices.
			The number of buildings monitored by Smart Meters.
		Economic	Increase in public incentives to finance photovoltaics.
			The number of municipal energy incentives for the area concerned
		Social	The number of people willing to do the proposed energy improvements.
			The number of events organized by schools to raise awareness and the number of families involved in the events.
UR BEROA, Spain	UR BEROA is a cooperative organization in the Bera Bera neighborhood of San Sebastian that specializes in local energy efficiency. Its main objective is to provide a sustainable energy plan that consists of three natural gas boilers, a cogeneration engine, a biomass boiler, and solar panels that produce hot water, which can be remotely managed based on the specific needs of each area.	Environmental	Number of speeches promoting environmental attitude in the yearly meetings
			Number of articles promoting environmental attitude in the bulletin of the cooperative
		Technical	Electricity generated by photovoltaics(KW)
			Share of rooftop surface covered by PV panels
		Economic	Reduction of the heating and hot water costs
			Subsidies achieved for housing energy efficiency improvements
		Social	Number of new members
			The ratio of subscriptions/de-subscription of cooperative membership
Coopérnico - Portugal	Coopérnico is a renewable energy cooperative in Portugal with over 1,000 members, including individuals, small and medium-sized businesses, and municipalities. Its objective is to engage its members in transforming the energy sector into a more renewable, socially equitable, and collaborative one.	Environmental	"Carbon Handprint" (complementary to "Carbon Footprint") measures the actions (political, economic, educational...) carried out by Coopérnico to encourage the reduction of the carbon footprint (among its members, in society in general).
			To reduce the carbon footprint in photovoltaic projects funded by Coopérnico(CO_2 emissions before and after investment).
		Technical	kWh marketed by Coopérnico.
			kWh produced in Coopérnico projects.
		Economic	No. of photovoltaic systems co-financed by co-members.
			No. and ease of access to public and private financial support for such energy efficiency interventions
		Social	No. of cooperative members.
			Level of compliance with cooperative principles (establishing for each one a metric of their own).
Virtual community-Germany	The Earnest App is an online application that aims to inform and educate its users about energy consumption and CO_2 emissions through interactive features, such as quizzes and challenges. Its goal is to prompt users to reflect on their energy and mobility habits, including the use of sustainable transportation options and reducing long-distance travel, with the hope that this understanding will lead to positive lifestyle changes related to energy efficiency.	Environmental	Assess and increase information on sustainable lifestyles available in the city of Darmstadt
			Collecting data on the diversity of community members
		Technical	Assess internet/app user behavior (numbers, time spent on the website, engaged with what information, etc.)
		Economic	Assess public funding opportunities for various different communities
			Increase funding programs for sustainability education in each region
		Social	Establish organizational headquarters
			Change school curriculum

and additional tools such as guided questionnaires, action research, school training projects, participant observation, administrator or policymaker interviews, and open data portals can be used to gather data. Feasibility is another critical aspect that needs to be considered when shortlisting CLIs, which requires careful consideration of what to measure, which unit is suitable for the measurement, where the indicator can be measured, what the data source could be, and what possible challenges might arise.

VI. Conclusion

The replicable workshop protocol effectively guided the co-design workshops and facilitated the creation of community-level indicators (CLIs). The template involved

activities and discussions that stimulated in-depth conversation, common goals, and actionable points. The workshop facilitators played a vital role in generating ideas and keeping the discussion on track. The co-design workshop is dynamic and may require facilitators to redirect the conversation if it goes off-topic. To overcome such challenges, the workshop plan established a timeline for objectives and actions and discussed energy sustainability and community involvement. Together, they identified goals and actions needed to achieve them, and subsequently, determined how to measure their progress. Challenges may also arise during the workshop, such as in one community, where the heat forced participants to move outside during the workshop as the workshop location was unusually hot.

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