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Participatory citizen science in solar energy research: going beyond data collection to promote the energy transition

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Abstract

Despite the societal relevance of energy research, there is a distinct lack of citizen science initiatives in the field. This paper reports the experience of a participatory and innovative strategy to develop a citizen science initiative for solar energy research. A number of stakeholders participated in the definition and implementation of the initiative, and tools such as surveys and a hackathon were employed. The process described aims to provide a blueprint for transforming the relationship between citizens and research into societal challenges. Here we describe the collaborative process and analyse the main opportunities, limitations and future perspectives.

Keywords

Citizen science; Environmental communication; Public engagement with science and technology

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Introduction — Energy transition and participatory science

The world is increasingly demanding a shift towards sustainable energy systems that use renewable sources like the sun to combat climate change and other pressing environmental and social issues. Although some technologies have seen major price drops and are now able to compete in the market alongside fossil fuel technologies, our societies are still a long way from fulfilling their energy demands using renewables. This is why Goal 7 of the Sustainable Development Goals (SDGs) defined by the United Nations is to ensure access to affordable, clean energies.

The involvement of citizens in research and innovation in solar energy is crucial, given the high environmental and societal relevance of the field. The energy transition has implications for jobs, wealth, health and political power, and depends entirely on the deployment of this type of energy. Involving citizens can act on several layers, from use and acceptance of technologies to influencing policy and governance [Stephens, 2019]. Activist groups have long called for the inclusion of civil society in the energy policy decision-making process as well as in research and innovation [Greenpeace, 2019]. Although a number of tools and methods

already exist to facilitate the participation of society in energy research [Jellema and Mulder, 2016], previous works have shown a clear lack of citizen science projects in the field [Wuebben, Romero-Luis and Gertrudix, 2020].

Previous public engagement research in the field has evaluated public perception and acceptance of technology and considered the members of civil society in their unique role as end users and data providers [Filippo et al., 2020]. Researchers and innovators have mainly explored the social acceptability of technologies and behavioural consumption patterns [Hobman and Ashworth, 2013; Marique et al., 2017], and many current citizen science projects focus on educational approaches[1] without a connection to ongoing research.[2] There seems to be a lack of enthusiasm or knowledge as to how to actively engage citizens in the clean solar energy undertaking and recognize their capacity to actively contribute to scientific endeavour and decision making.

Citizen science can play an important role in this transformation and in building the capacity to support more democratic processes in energy research and innovation [Sauermann et al., 2020]. Referring to the active involvement of non-scientists in different phases of the scientific process, often data collection or analysis [Bonney, Cooper et al., 2009; Kullenberg and Kasperowski, 2016], citizen science can be categorized into three practices: contributory, collaborative and co-creative. Co-created citizen science initiatives are the most participatory of the three models, in which citizens not only collect data, but may also help to refine the research design, analyse data or disseminate findings [Bonney, Ballard et al., 2009].

Following a co-creative approach, we explored a participatory and innovative strategy for the creation of a citizen science initiative in the solar energy field, identifying the main opportunities and barriers involved in such a practice and, above all, providing a practical case study to encourage further actions in the field. This paper describes the strategy and the resulting initiative, Generation Solar.

A participatory process for implementing citizen science in solar energy research

Generation Solar was designed and developed as part of the EU-funded project GRECO (https://www.greco-project.eu/citizen-science-app/), with the goal of becoming a paradigm for transforming the relationship between citizens and researchers working to address the societal challenge of secure, clean and efficient energy. The process, which can be described in five steps, was carefully designed to involve diverse stakeholders, including citizens, companies, research centres and universities.

For the purpose of generating a *participatory* citizen science initiative, the research question was designed collectively, involving diverse actors to encourage creativity while addressing their particular interests and concerns. First (1), we surveyed 90 professionals related to the solar energy field: researchers, policymakers and engagement experts, among others. We asked them about the ways in which citizens could actively collaborate with researchers in the field, the main constraints to persuading citizens to adopt solar energy innovations, and what research could and should give in exchange to civil society. The results from this survey were

[1] Z-Nev project: https://scistarter.org/project-z-nev-zero-net-energy-vessel.
[2] NOVA Lab on Energy: https://www.pbs.org/wgbh/nova/labs/lab/energy/.

analysed and compiled into a document which is publicly available [Cristóbal, 2019]. The document compiled a handful of ideas for research lines with a participatory perspective and served as a starting point for the next step of the process.

Second (2), we organized an online hackathon to design a citizen science project based on the results from the previous step. In a hackathon, participants are brought together to engage in brief, intensive collaborative work to solve a challenge. Hackathons were traditionally linked to software or IT development, but in recent decades they have been increasingly used across all disciplines and proven their power to facilitate knowledge exchange and broader problem framing [Briscoe and Mulligan, 2014; Ghouila et al., 2018]. We received 62 registrations from 15 countries around the world, distributed among 30 teams. An open source e-learning software called Chamilo (https://chamilo.org/en/) was used to interact with the participants and provide them with the input materials and instructions. Twelve practicable plans for launching a citizen science initiative in the solar energy field were submitted one week after the launching event.

Third (3), the proposals received were quantitatively evaluated according to six criteria by a multidisciplinary committee [as published by Cañizo et al., 2021]. The proposal with the highest score was selected for implementation during the project. The author of the proposal was compensated with a prize and their idea disseminated via the project channels. The winning proposal described the consolidation of an open database of rooftop solar installations, as will be described later on.

Fourth (4), the winning initiative was co-developed with a tech company, some of the hackathon participants, two solar energy research institutions and a science communication team. Continuous feedback was also received from GRECO project partners and an advisory board comprised of representatives of European universities, research centres, science communication agencies, professional and civic associations, and public institutions. This allowed for a wider perspective. Leading on from this fourth step, the "Generation Solar" app was launched to coincide with Earth Day 2020.

In the fifth and final step (5), the initiative is currently being disseminated, the data collected is being linked to research, and improvement and sustainability actions are being considered.

Generation Solar — a citizen science app for solar energy research

Generation Solar, the outcome of our participatory citizen science initiative, is an app linked to a web platform that aims to co-create an open database of solar photovoltaic installations. It invites owners of domestic solar installations and any other person with access to public or private panels (such as a hospital, a school, a company or similar) to register their installation and its technical characteristics. Generation Solar responds to a clear scientific demand, as an important drawback for researchers working on energy modelling and predictions is precisely a lack of information about the locations and specific characteristics of solar installations.[3]

[3]Researchers in the field model the generation of energy from the sun in different European countries assuming a uniform distribution of rooftop installations because no better information is

Moreover, the app creates a network of solar energy users or interested parties who can use the internal chat feature to engage in conversation, exchange information and spread the word on the use of solar energy in a certain city or region. Although this interaction has been small, as will be discussed in the Challenges section below, this tool has served to correct mistakes in the reported data. Both the app and the public web platform provide people with access to an online map they can use to visualize all the reported installations and their details, make contact with others, and obtain descriptive data on CO_2 emissions saved as a result of the energy produced by the reported panels and the total energy capacity installed. To date, the platform has more than 300 registered users and 136 installations across eight European countries (Figure 1). The web version of Generation Solar can be accessed via http://generationsolar.ies.upm.es/ while the app version is available in the app stores for both Android and iOS.

Figure 1. Generation Solar, a citizen science app for solar energy research and communities.

publicly available at the moment [Victoria and Andresen, 2019]. Some databases exist but they are private, include information from very few countries, and lack important data such as the exact orientation and inclination of the panels.

Opportunities

With this experience, we are helping to establish a pool of practices for engagement in research into clean and affordable energies and support a mission to promote citizen science that goes beyond data collection. Ryghaug, Skjølsvold and Heidenreich [2018] have shown that certain artefacts, such as solar panels, may become objects of participation and engagement, and that their introduction into engagement efforts may foster material participation and energy citizenship. This process can be replicated in any other research field and appears highly relevant for the promotion of citizen science in technological sectors and engineering, in which citizen science has been explored far less widely than in biological or medical sciences.

Although currently small, a group of people engaged in the energy transition and with the potential to establish an empowered community has already been created around Generation Solar. This has a lot of potential, as other studies and reports have shown [Campos and Marín-González, 2020], because active citizens can influence the trajectories of the energy transition and act as agents of change in the transition towards a more decentralized, democratic, inclusive, fair and sustainable energy model. We believe that Generation Solar and the process behind it supports this movement. Moreover, it promotes open science practices and brings energy researchers closer to participatory science communication efforts. Other studies have revealed a strong reluctance on the part of energy researchers to interact with non-academic audiences [Barbosa et al., 2021]. Through their participation in the process which resulted in Generation Solar, researchers from the project GRECO realized that the inclusion of citizens can benefit their work and develop interest in the field. This and similar experiences may help overcome tensions between citizen science and traditional academic science.

Challenges

A number of barriers and limitations also became evident during the process. First, the participatory process that led to the creation of Generation Solar, although directed at diverse stakeholders, was dominated by academics. The winning proposal in the hackathon, for instance, was submitted by a solar energy researcher. This person considered the input collected from different perspectives in a previous step of the process, but approached the proposal responding to their own research needs. This raises the question of whether the challenge addressed in the hackathon was already too technical, and whether the online format chosen was suited to the diverse audience we expected. The same question can also be used to reflect on the limitations of online citizen science, as in the case of Generation Solar, to reach different people, potentiate dissemination and maintain engagement.

Since the process of conducting our citizen science initiative required a relatively long period of time (more than a year), we did not expect the people who participated in the hackathon to also take part in the data collection process. This is explained by a certain "fatigue" that has been documented in other engagement efforts when citizens are invited to take part in similar activities, such as surveys [Geoghegan et al., 2016]. In fact, very few people who took part in the hackathon went on to participate in the data collection stage of Generation Solar. Future works should explore the impact of citizen science formats (offline, hybrid or online) on citizen scientists [Aristeidou and Herodotou, 2020], as well as aspects of accessibility, equity and diversity related to such efforts [Cooper et al., 2021]. Nonetheless, our experience highlights the importance of opening up the process

well in advance, making it participatory as early as possible in order to ensure a diversity of views and, most importantly, shared accountability in research and innovation.

Probably the biggest challenge of this initiative is the transfer of knowledge into tangible actions. As for the data collected, there were conflicting expectations between researchers and the communication and dissemination team. In order for the data collected to have a solid use in energy modelling, researchers expressed the need to increase the numbers of Generation Solar users to several thousand. Given the very specific profile of Generation Solar participants and the chosen format for the initiative, reaching this goal presents quite a challenge. From the network point of view, the number of users should also increase to provide local or regional incidence. We believe, however, that even a small number of users can act as ambassadors to promote Generation Solar. Given that it achieves geographical representation, the database can serve as evidence of solar energy deployment in a certain region. In addition, schools, science centres and solar energy companies can use Generation Solar as a tool to discuss the importance of using solar power. We have considered actions to increase the reach of the initiative, and future efforts could focus on engaging specific groups such as energy communities. These communities democratize power, often by giving members of open organizations opportunities to plan, finance, own or manage energy systems and services [Capellán-Pérez, Campos-Celador and Terés-Zubiaga, 2018].

Future perspectives

An important line for future work lies in forging alliances between citizen science projects in the field and citizen energy communities [Wuebben, Romero-Luis and Gertrudix, 2020]. The most effective communication channels, methods and technologies for aligning citizen science with the goals of citizen energy communities and amplifying the impacts of citizen participation in the energy transition have yet to be clarified.

Future works should address institutional and, perhaps, legal constraints related to open data and privacy. The relationship with utilities is also yet to be explored, as we anticipate the creation of possible conflicts with utilities and energy companies, which traditionally have collected and owned data, such as data from solar installations, some of which hold private information and can also have financial value [Wuebben, Romero-Luis and Gertrudix, 2020]. However, our experience indicates that some companies, like service providers, are willing to collaborate with citizen science initiatives although the benefit to themselves remains unclear.

In our experience, the different citizen science models serve a variety of purposes and should be considered holistically in order to distance citizen science from mere data collection or crowdsourcing. However, it is important to highlight that participatory processes are time-consuming and probably more challenging due to the diverse expectations and interests of the stakeholders. Gunnell et al. [2021] offer the following analysis:

> *"Co-created citizen science offers practical tools for implementing science communication theories by increasing public participation in scientific research, empowering communities and advancing situated scientific knowledge. However,*

delivering such an approach presents a number of key challenges around funding, fostering working partnerships between scientists and citizens and ensuring all stakeholders receive sufficient benefits from the process."

We believe that this type of initiative showcases the power of citizen science to support complex sustainability transitions in areas such as renewable energy by combining increased scientific knowledge production and bridging the perceived gap between science and society [Sauermann et al., 2020]. Generation Solar has yet to extend its reach, and further evaluation data needs to be collected to prove this claim. However, as highlighted by Sauermann et al. (2020), the needed transitions can occur through collective problem identification and agenda setting; mobilization of resources; and the facilitating of socio-technical co-evolution, all of which Generation Solar has taken into account. Citizen science actions such as ours must address important challenges if they are to realize this potential. These challenges may include increasing the diversity, level and intensity of participation; addressing the social and technical nature of sustainability problems; and reducing tensions between participatory processes and traditional academic science. The path ahead will be long, but we believe that this process serves as inspiration to begin paving the way.

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