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Can citizen-financed photovoltaic projects support the energy transition? Experimental evidence from Swiss households

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ABSTRACT

Photovoltaics (PV) is a widely accepted technology that has a vital role to play in the energy transition. However, residential and community-owned installations are not accessible to everyone. Citizen-financed PV projects (CiFi PV) offer opportunities for tenants, individuals with limited upfront investment capacity, and homeowners with unsuitable rooftops to invest in PV installations.

To evaluate the attractiveness of CiFi PV and its influencing factors, we conducted two online experiments with representative samples of the Swiss population. The first experiment ($N = 807$) analyzed the impact of four project characteristics (minimal investment, pay-out model, rooftop type, provider) on perceived attractiveness of CiFi PV projects. The second experiment ($N = 512$) examined the effect of seven motivational frames and a control frame on the same dependent variable. Both studies also evaluated willingness to invest.

Over half of respondents were willing to invest in CiFi PV projects, primarily to support solar power and renewable energy generation. The main deterrent was uncertainty about the provider's trustworthiness. Neither project characteristics nor motivational frames significantly influenced perceived attractiveness. While financial and societal impact motivations were significant in the first experiment, the motivational frames in the second did not significantly affect attractiveness.

These results indicate that CiFi PV projects have a strong diffusion potential because they can effectively engage various kinds of individuals in terms of socio-demographic and motivational attributes. To do so, there must be more of such projects, and they must be made more visible by practitioners and policymakers. Enhancing regulatory framework conditions can further improve project development.

1. Introduction

Global efforts to mitigate climate change have led to an increased focus on renewable energy, with the primary goal of reducing the dominance of fossil fuels in the energy system. Photovoltaics (PV) play a crucial role due to their substantial potential and widespread societal acceptance [1–3]. Falling prices and advancements in PV technology have led to significant growth in the PV industry, making it the least expensive source to replace fossil fuel energy [4]. In Switzerland, however, the proportion of PV is not yet increasing as much as it could. Recent growth in the Swiss PV market has mainly been fueled by utility companies, who can make significant upfront investments [5], and homeowners who have access to suitable rooftops [6], primarily promoting small-scale PV plants. For PV's potential to be fully exploited,

expanding the target groups and focusing on large-scale plants is necessary. Large-scale plants, however, are socially less accepted and require larger upfront investments [7,8].

Citizen-financed photovoltaic projects (CiFi PV) have emerged to address this gap [5,9–13]. These essentially “crowdfunded” projects allow for broader public participation in developing large-scale PV installations, as they reduce the financial means necessary to participate in them and enable individuals without a suitable and accessible rooftop to participate. Moreover, the broader financial participation can further increase social acceptance of a PV installation [14,15], which is especially relevant for projects of larger scale [8] or situated in alpine areas [16]. From a project developer perspective, CiFi PV projects potentially increase a project's social acceptance, close financial gaps, and bind clients or members [17].

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In return for their investment, the CiFi PV investors receive their investment sum back after a specific project duration, usually earning small monetary gains due to interest rates or a share of the solar power produced [5,10,18,19]. These projects enable individuals to invest relatively small amounts of money, and to contribute to and benefit from solar power without needing private rooftop installations or more active involvement as in the case of e.g. community energy projects [5,20,21]. Although these initiatives currently represent a relatively small portion of the overall PV market, they have the potential to democratize the production of solar power and accelerate its deployment.

For CiFi PV projects to achieve wider adoption and impact, it is essential to understand what factors drive individuals to invest in these kinds of projects. Literature focusing on CiFi PV projects has primarily analyzed motivational factors [5,10,11,20,22–24], and has found that various impact-oriented and benefit-generating factors play a key role in the adoption process. Recent studies based on inferential statistics and larger samples have shown that it is principally financial factors [5,20], environmental factors [5,22], and local value creation [5] that positively influence willingness to invest. Primarily referring to positively connotated outcomes, such as financial gain, protection of the environment, promoting local actors, etc., these factors can be conceptualized as motivational attributes of CiFi PV projects [5,25,26]. While motivations influence participation, the role of project characteristics, such as pay-out model, financial return, minimal investment sum, provider type, project duration, and project location have only marginally been studied [27]. CiFi PV projects are highly diverse and include rooftop or ground-mounted locations [5,28,29]. A study by Stauch and Gamma [30] tested two different remuneration models (electricity versus financial compensation) in an experimental design, showing that both models may appeal to the broad population but attract individuals with different motivations. Specifically, they found that pro-environmental individuals preferred to receive solar power produced by their co-financed installation, and less environmentally driven individuals chose financial compensation without access to the energy produced. The selected experimental design, however, did not include a fully developed CiFi PV offer and thus did not test for any project characteristics besides the electricity versus remuneration pay-out model.

Overall, there is little understanding of the factors influencing the adoption of CiFi PV projects. This study aims to fill this research gap by investigating the influence of (a) project characteristics in the first experiment and (b) motivational frames based on motivational project attributes in the second experiment on CiFi PV project attractiveness. We conduct two experiments based on a hypothetical CiFi PV project strongly informed by existing CiFi PV projects. With this, we believe we are providing a more realistic experimental setting and gaining more robust insights into the diffusion potential of such projects. Second, this paper combines the analysis of both project characteristics and motivational frames on perceived project attractiveness.

This paper draws on two representative samples of potential adopters in Switzerland. Switzerland is an interesting case as the estimated solar power potential of almost 54 TWh from Swiss rooftops is still heavily underexploited [31]. At the end of 2022, the annual solar power output accounted for only 4.6 TWh [32]. Large-scale PV plants are necessary to unlock this potential, and CiFi PV bears significant potential to contribute to its development. While representing around 50 projects in 2022 and currently occupying a niche position in the overall PV market [5,10,17], these projects will likely expand further under the recently adopted Federal Act on a Secure Electricity Supply from Renewable Energy Sources (2024). This legislation facilitates large-scale PV development through harmonized permitting processes, identifying prioritized areas for energy production, and introducing “local electricity communities” (LECs), enabling local power production and sharing across property boundaries. With that, it facilitates auto-consumption, which in turn reduces dependence on regional feed-in tariff variations and lowers costs related to the electricity grid.

Additionally, the Swiss case is of interest, as its population comprises around 60 % of tenants [33] currently excluded from accessing residential PV installations.

In the following, we first introduce CiFi PV projects more thoroughly and then provide a theoretical background to the project characteristics and project framing outlining our research questions and hypotheses. Next, we present the methods and results of the first experiment (impact of project characteristics) and the second experiment (impact of motivational frames). We conclude by discussing our results and outlining avenues for future research.

2. Theoretical background and hypothesis development

2.1. Citizen-financed PV projects and expansion potential

From a project developer perspective, CiFi PV models have the potential to close a financial gap for new installations, enhance social acceptance of large-scale PV plants, and integrate tenants in particular into PV development [17,34]. In Switzerland, around 60 % of the population are tenants, and a similar proportion is seen in other European countries such as Germany, Austria and Turkey [33]. As such, CiFi PV projects enable developers to access large shares of the broader population, thereby increasing their chances of financing a new installation and improving the project's social acceptance [5,13]. The projects are provided by various kinds of project developers, including energy utilities, private companies, startups, cooperatives, associations, and municipalities [5]. These can be broadly categorized as market-oriented (commercial providers) or grassroots-oriented (non-profit providers) projects [5,35]. As different provider types develop and offer CiFi PV projects, they vary widely in their project characteristics, such as minimum investment sum, pay-out model, location, and project duration.

From the public's perspective, CiFi PV projects are often more accessible than private rooftop installations or community energy initiatives. This is mainly because of the co-financing mechanism that allows individuals to invest small amounts of money instead of dealing with high up-front costs and because individuals do not need to own a suitable rooftop or be part of the local community. In return for their investment, participants receive their money back over time and often gain an economic benefit. This can occur via the restitution of the invested sum, including an interest rate or via a reduction on the electricity bill, which is in effect a form of indirect solar power consumption. Most of these projects do not provide the investors directly with the solar power produced, though this may differ in local cooperatives [5,10,29,30].

Co-financed PV installations are often subsumed under the umbrella term “community energy” projects [18]. It is, however, important to note that most of these projects do not possess a community character. Here, participating individuals usually do not know the other cofinancers.¹ Consequently, these projects do not primarily aim at community, but rather collective, action based on individual participation. As shown by Sierro and Blumer [17], CiFi PV participants do not appear to be motivated by community-related aspects but by the opportunity to individually contribute to solar power deployment through a low-effort participation in line with personal values. Other studies show that drivers for CiFi PV adoption are heterogeneous and potentially attract different kinds of people [5,10–12,23,24].

While CiFi PV thus has strong potential for expanding PV by including a larger share of the population, these projects still represent a niche, accounting for only 0.05 TWh of the nationally produced 2.8 TWh

¹ Some project developers organize inauguration events for co-financed installations. We do not consider this a community project because these opportunities for CiFi PV participants to meet are optional but not required by the project or the developer. Moreover, these meet-ups are selective and are not intended to be a regular community activity.

in 2021 [36,37]. In this study, we aim to answer the following research questions (RQ):

RQ1a. To what extent are individuals willing to invest in a CiFi PV project?

RQ1b. What reasons inform this decision?

In the following, we present our research questions and the development of our hypotheses regarding the experimental setting and the role of project characteristics and motivational frames.

2.2. Hypotheses on the role of project characteristics

A project's characteristics can attract different kinds of people, depending on its resonance with the individuals' underlying preferences, motivations, and values [30]. According to its design, a project may be perceived as accessible and desirable, motivating varying forms of involvement. In the context of CiFi PV, project characteristics potentially influence a project's perceived attractiveness, informing the process of deciding whether or not to make an investment [30]. So far, there has been little research on such characteristics in the CiFi PV context. We thus formulate the following research question, which we address in our first experiment:

RQ2. Do project characteristics influence the perceived attractiveness of a CiFi PV project?

CiFi PV projects are based on financial participation. We therefore expect that various finance-related project characteristics may determine how a project is perceived and whether individuals decide to invest. Based on each individual's availability of liquid savings, the minimal investment sum determines whether a project is accessible. Consequently, we test whether a too-high investment sum may crowd out potential participants. We hypothesize that a low investment sum increases the attractiveness of CiFi PV.

Hypothesis 1. A project with a low investment sum is more attractive than one with a high investment sum.

Furthermore, the pay-out model may influence project adoption [30]. CiFi PV markets currently encompass four main pay-out models: equity, lending, reward, and donation [5,29,30]. The first two are return-based models and usually promise a monetary benefit to the participants. Equity models distribute gains based on the installation's effective productivity. Lending models function with a fixed interest rate over time. Reward models can provide an economic benefit by reducing the electricity bill or a non-monetary reward in kWh. As the Swiss electricity market is currently not liberalized, reward models require attachment to an energy provider. They are either directly provided by an energy utility or via another provider in collaboration with one. Lastly, donations may provide non-monetary benefits, such as symbolic returns (e.g., a solar vignette). In this experiment, we focus on the two "investment-like" pay-out models, equity and lending, which do not depend on a liberalized energy market. Consequently, such models offer more potential for mainstreaming across various countries. Fleiss and colleagues [20] showed that investment security is a determining factor in adopting CiFi PV. Lending models provide more investment security than equity-based models [14], because the monetary gain and the payback date are pre-determined. We thus expect the lending model to be more attractive than the equity-based model.

Hypothesis 2. A CiFi PV project based on a lending pay-out model is more attractive than a project with an equity-based model.

Another influential project characteristic is the provider. In line with Chan and colleagues [38], the provider determines the management, ownership, and benefit distribution of a CiFi PV project. Moreover, the perceived trustworthiness of the provider has been found to be an essential factor in participation in renewable energy projects [39]. CiFi

PV projects are offered by various providers, ranging from energy utilities, private companies, municipalities, and cooperatives. The first two are usually market-oriented, while the others are grassroots-based [35]. In this experiment, we aim to test whether a "market" or a "grassroots"-oriented provider influences the willingness to participate in a CiFi PV project. In Switzerland, several hundred energy utility companies exist [40,41], of which most are independent companies primarily owned by municipalities, cities, and cantons. This means they are ultimately governed by citizens and considered locally rooted and well-known in the local community [16,42]. Additionally, this ownership structure provides more financial security than grassroots organizations. It can cross-finance with other businesses or governmental structures in the event of financial difficulties.

Hypothesis 3. A CiFi PV project developed and offered by a market-oriented organization such as an energy utility has a higher project attractiveness than one provided by a grassroots-oriented organization.

Finally, the PV installation is not built on the participant's roof, but elsewhere. For CiFi PV projects to be economically viable, they require a large surface and, ideally, a high in-house electricity consumption [5]. Thus, rooftop partners are usually either industrial or municipal. Based on interviews with Swiss CiFi PV participants, Sierro and Blumer [17] found that the rooftop partner can be a source of motivation for participants, specifically where the individual's values and the rooftop partner's align. Thus, we test two different settings: a PV installation on a school building, representing a municipal rooftop partner and a place that may be emotionally close to individuals (especially for those with children of school age), and on top of a petrol station, representing an industrial rooftop partner and the use of fossil fuels. We hypothesize that a school building would be perceived as a smart combination of solar power production and educational purposes with more chances to evoke positive emotional associations than a petrol station, which is more likely to be linked to unsustainable energy use.

Hypothesis 4. A project with a municipal rooftop partner is more attractive than one with an industrial rooftop partner.

2.3. Hypotheses on the role of motivational project framing

Framing is commonly used to emphasize specific aspects of an issue, influencing people's perceptions and attitudes toward the matter [43,44]. In other terms, frames help guide the audience toward a specific understanding of a product or service [45]. In renewable energy projects, framing can be used as a communication tool to increase social acceptance and to motivate people to get involved [46]. Some frames emphasize qualitatively different but potentially relevant considerations (referred to as emphasis frames) while others display logically identical information differently (equivalence frames) [44,47,48]. Wolske and colleagues [49] tested the latter, in the form of temporal and gain/loss framing, in the adoption of residential photovoltaics. Their results indicate that their equivalence frames did not influence residential PV adoption. Instead, they found that the respondents' underlying motivations and predispositions determined their willingness to adopt residential solar, thus overriding the effect of equivalence framing. Following this line of thinking, we argue that the motivational attributes of CiFi PV may influence the project's perceived attractiveness. Within this context, we understand 'motivational framing' as a communication technique that highlights specific attributes, such as financial or environmental benefits, predominantly for marketing purposes. Consequently, we employ emphasis frames based on motivations that have been shown to affect the decision-making process and ask the following research question:

RQ3. Do motivational frames influence the perceived attractiveness of a CiFi PV project?

Framings generally induce an overall negative or positive tone,

depending on their formulation [44]. This inherent valence can potentially impact decisions such as an investment [44,45]. While studies have shown that loss framing is more effective in stimulating green intentions and behaviors (see the literature review [50]), we argue that project developers need to present a comprehensive and realistic future to promote project participation [51], in this case investment in the context of CiFi PV. A motivating frame outlining positive impact should thus induce positive attitudes toward the project and potentially toward individual investment. Moreover, it seems impractical to describe motivational attributes found to be relevant in the context of CiFi PV, such as security of investment, monetary gain, etc. in a loss framing, as individuals can easily live without CiFi PV projects. Thus, motivating CiFi PV investment by formulating motivational frames based on loss seems irrelevant. Consequently, we hypothesize that emphasis frames based on positive motivational attributes of CiFi PV projects increase a project's attractiveness.

Hypothesis 5. Motivational frames result in higher project attractiveness compared to the absence of an emphasis frame.

To build our motivational frames, we consulted existing research regarding the drivers underlying CiFi PV participation. Financial benefits, such as attractive interest rates, security of investment, and no long-term binding of the invested capital were identified as critical drivers [5,20]. Environmental protection [5,22,23], civic engagement [23], local value creation [5,10], and energy independence through local energy production [10,17] have also been found to influence people's willingness to participate in CiFi PV projects. Looking at developments in the study of investment behaviors, it can be observed that impact investment has gained in popularity in recent years. Moreover, impact investment has become important for sustainable development [52]. Because CiFi PV projects aim to promote photovoltaic development through tangible, large-scale projects and build on investment mechanisms (equity, lending), they could be conceptualized as an impact investment, linked to motivations more strongly related to the investment itself and its tangible and defined impact.

To summarize, recent literature on CiFi PV indicates that its adoption can be motivated by substantively different factors. This is in line with emphasis framing, as described above. Three studies provide statistical evidence on motivations driving CiFi PV involvement. They indicate that financial [5,20], environmental [5,22], and local-value creation benefits [5] in particular lead to a higher willingness to participate in CiFi PV. Consequently, we formulate the following hypothesis:

Hypothesis 6. Among the motivational frames, the emphasis frames focusing on finance, environment, and local value creation result in the highest project attractiveness compared to the other motivational frames.

Table 1 provides an overview of the research questions and related hypotheses. In the following, we present the methods and results of our first experiment, addressing our first and second research questions regarding the influence of project characteristics on perceived project attractiveness (Section 3). Next, we describe the methods and results of our second experiment regarding our first and third research questions on the influence of motivational frames (Section 4) before discussing the results.

3. Experiment 1: the role of project characteristics

3.1. Method and experimental design

We first conducted an online experiment with $N = 807$, testing the influence of varying project characteristics on a CiFi PV project's attractiveness. We employed a $2 \times 2 \times 2 \times 2$ factorial design with the following attributes: provider type, minimum investment sum, pay-out model, and rooftop partner (see details in Section 3.1.1 below and Table 2). All other parameters were kept constant. The experimental

Table 1

Overview of the two experimental studies, their corresponding research questions, and hypotheses.

Experimental study	Research question (RQ)	Hypotheses (H)
Experiments 1 & 2	(RQ1a) To what extent are individuals willing to invest in a CiFi PV project?	None
Experiments 1 & 2	(RQ1b) What reasons inform this decision?	None
Experiment 1	(RQ2) Do project characteristics influence the perceived attractiveness of a CiFi PV project?	<ul style="list-style-type: none"> • H1: A project with a low investment sum is more attractive than one with a high investment sum. • H2: A CiFi PV project based on a lending pay-out model is more attractive than a project with an equity-based model. • H3: A CiFi PV project developed and offered by a market-oriented organization such as an energy utility has a higher project attractiveness than one provided by a grassroots-oriented organization. • H4: A project with a municipal rooftop partner is more attractive than one with an industrial rooftop partner.
Experiment 2	(RQ3) Do motivational frames influence the perceived attractiveness of a CiFi PV project?	<ul style="list-style-type: none"> • H5: Motivational frames result in higher project attractiveness compared to the absence of an emphasis frame. • H6: Among the motivational frames, the emphasis frames focusing on finance, environment, and local value creation result in the highest project attractiveness compared to the other motivational frames.

Table 2

Independent variables: Overview of the variation of different project characteristics (attributes and attribute levels).

Project characteristics (attributes)	Attribute levels
Provider	<ul style="list-style-type: none"> • Commercial enterprise: "SunEnergy AG (plc)." • Cooperative: "Cooperative SunEnergy"
Minimum investment sum	<ul style="list-style-type: none"> • "CHF100" • "CHF750"
Pay-out model	<ul style="list-style-type: none"> • Lending: "Loan" • Equity: "Investment"
Rooftop partner	<ul style="list-style-type: none"> • "Petrol station" • "School building"

project design reflects offers currently existing in the Swiss market and has been validated by actual project developers to make sure that the setting is realistic.² We further pre-tested the study design and the distribution of the dependent variables with a small sample of the Swiss population ($N = 163$). Minor adjustments were made, especially in the introductory parts of the survey explaining the CiFi PV project model. The final experimental project offer was designed with basic information

² Eight CiFi PV project developers from the French and German-speaking parts of Switzerland (utilities, cooperatives, start-ups, and municipalities) were part of the research project [37].

regarding the expected annual production, the length of the project, the experimental treatment information, and a fictional head of the project (translated from the originals in German/French) (see Fig. 1).

To answer our first research question regarding the CiFi PV adoption rate, we used a binary variable to measure willingness to invest (“Yes, probably”/“No, probably not”) and analyzed it descriptively. For the second research question, we employed an ANCOVA model to measure the effect of the experimental treatments and covariates (independent variables) on the perceived attractiveness of the project (dependent variable). Furthermore, we included a manipulation check. In the following, we present the experimental design, the survey flow, data collection and analysis, and the sample’s description in more detail.

3.1.1. Experimental design

3.1.1.1. Independent variables. Table 2 summarizes the experimental treatments used as independent variables in the subsequent ANCOVA analysis. We chose a 2 × 2 × 2 factorial design with attributes as experimental treatments based on existing research (see Section 2.2 for details). For the minimum investment sum, we opted for CHF 100 as the “low investment sum” and CHF 750 as the “high investment sum” to ensure sufficient difference but potentially a normally distributed variance. As shown in Fig. 1, the treatments were either highlighted in bold

or reinforced by a dual display (e.g., provider name).

3.1.1.2. Dependent variables. In line with our second research question, and for testing hypotheses 1–4, we used the perceived attractiveness of the displayed CiFi PV project as our dependent variable. For its measurement, we employed a scale based on three statements: “I find the offer attractive,” “The offer appeals to me,” and “I am interested in that offer.” Respondents could answer on a Likert scale from 1 to 7 (1 = “I completely disagree”; 7 = “I completely agree”). We conducted a reliability analysis, yielding an excellent score of Cronbach’s α = 0.88. We employed the computed attractiveness scale as the dependent variable for the subsequent ANCOVA analysis.

3.1.1.3. Covariates. To account for influence stemming from factors such as sociodemographic variables, we included the following covariates in addition to the experimental variables: age, gender, education, income, political orientation, linguistic region (Swiss-German/French), living area (rural or city/agglomeration), and living situation (homeowner, tenancy, cooperative). We further included motivational attributes of CiFi PV, energy crisis perception, experience with CiFi PV, and liquid savings as covariates.

CiFi PV’s motivational attributes were measured using the scale developed by Sierro and Blumer [5], adapted from Noppers and colleague’s motivational scale for measuring the adoption of sustainable innovations, such as electric vehicles [25,26]. Respondents were asked to rate their agreement about statements on the motivational attributes of participation in CiFi PV projects on a scale from “1 = Completely disagree” to “5 = Completely agree.” Specifically, we inquired about financial, environmental, and local value creation and symbolic motivational attributes for CiFi PV adoption. For example, respondents rated their agreement with an environmental motivational attribute such as: “Through participation in a CiFi PV project... I protect the environment” (see Table 3 for the full scale). In addition to the attributes from the adapted Sierro and Blumer [5] scale, we added three items measuring motivational attributes related to energy independence and security: “... I promote the independence of the Swiss electricity supply”, “...I am sending a political signal,” and “...I contribute to the implementation of Switzerland’s energy strategy.” A principle component analysis yielded a three-dimensional solution instead of the expected five-dimensional solution (see Table 3). Symbolic and financial motivational attributes loaded on two factors corresponding to the theoretical categories. However, local value creation, environmental, and energy security attributes loaded on a single factor with two items loading on two factors simultaneously. These two were excluded from the subsequent analysis (in gray). The remaining components were subsumed in a factor representing societal impact motivational attributes. Consequently, we included financial, symbolic, and societal impact motivational attributes as independent covariates in the ANCOVA model.

We used an exploratory question regarding the respondents’ perception of the current energy situation because at the time of the survey, energy prices were highly volatile due to the war in Ukraine and the ensuing restrictions on fossil fuel trade with Russia [53]. Respondents were asked to indicate their agreement with the following four statements on a scale from “1 = Completely agree” to “5 = Completely disagree”: “Thinking about a possible power shortage this winter is unpleasant for me,” “I’m apprehensive about a possible power shortage this winter,” “Media reports about a possible electricity shortage this winter make me nervous and tense,” and “I am confident that the responsible institutions will ensure a reliable power supply this winter.” The last item was reverse-coded for analysis. A reliability test yielded a good Cronbach’s α = 0.8 when leaving out the reverse-coded fourth item. Consequently, we computed the energy crisis perception scale based only on the first three items and included it as a covariate.

The number of past investments accounted for experience with CiFi PV: none, single investment, and multiple investments. At the time of the

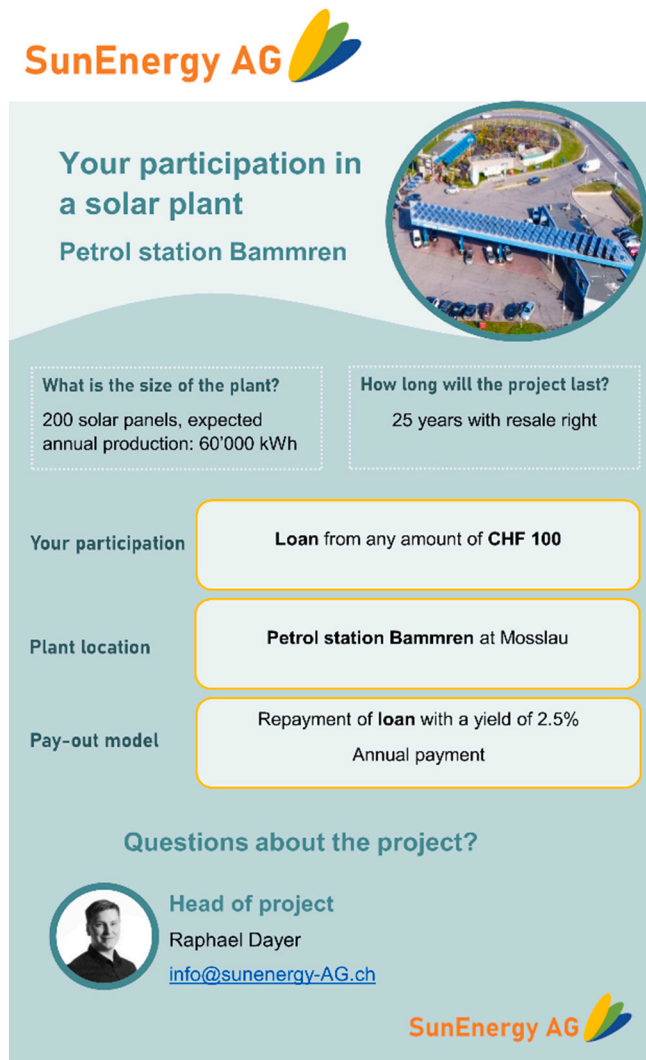


Fig. 1. Illustration of the experimental CiFi PV project (varying attributes are bold or a logo). Translated from the originals in German/French.

Table 3
Component loadings based on a principal component analysis of the motivational attributes scale (loadings below 0.3 suppressed).

Theoretical category	Item	M / SD	Component loadings			
			Factor 1	Factor 2	Factor 3	Final coding
Symbolism	Differentiating myself from others	2.59 / 1.13			0.778	Symbolic
Symbolism	Showing who I am	2.14 / 1.13			0.835	Symbolic
Symbolism	Saying something positive about myself	2.90 / 1.16			0.765	Symbolic
Finance	Controlling where my money flows	3.52 / 1.07		0.687		Financial
Finance	Making a financial gain	3.11 / 1.00		0.77		Financial
Finance	Investing my money safely	3.13 / 1.00		0.742		Financial
Local value creation	Financing the implementation of a tangible project	4.02 / 0.92	0.487	0.484		Excluded
Local value creation	Having an impact together with others	3.95 / 0.95	0.686			Societal impact
Local value creation	Supporting local actors	3.72 / 0.97	0.454	0.457		Excluded
Local value creation	Contributing to the sustainable development of my region	3.83 / 0.99	0.59	0.311		Societal impact
Environment	Protecting the environment	3.89 / 0.97	0.801			Societal impact
Environment	Fighting climate change	3.74 / 1.08	0.788			Societal impact
Environment	Reducing CO ² emissions	3.87 / 1.01	0.784			Societal impact
Energy security	Promoting an independent Swiss electricity supply	3.98 / 0.92	0.671	0.333		Societal impact
Energy security	Sending a political signal	3.27 / 1.21	0.546		0.341	Societal impact
Energy security	Contributing to the implementation of the Swiss energy strategy	3.84 / 0.97	0.75			Societal impact

Note: N = 807; extraction method: principal component; varimax rotation; 3 components extracted, explained variance = 60 %; Kaiser-Meyer Olkin = 0.92; Bartlett test of sphericity: $p < .01$, Cronbach's $\alpha = 0.72$.

survey, liquid savings were measured as follows: “none,” “below CHF 5,000,” “between CHF 5,001 and 20,000,” “between CHF 20,001 and 50,000,” “between CHF 50,001 and CHF 100,000”, and “over CHF 100,000.”

3.1.2. Survey flow and descriptives

Respondents were first presented with a short introduction to CiFi PV models. Next, they were shown a specific project (see Fig. 1 for an example) and asked to study it carefully. Participants were randomly assigned to different project offers with varying characteristics (between-subjects design) and asked to rate their willingness to invest with a binary variable (“Yes, probably”/“No, probably not”). Next, they were asked to indicate their perception of the project's attractiveness (dependent variable in the ANCOVA model).

Depending on their answer to the binary question on their willingness to invest, participants were presented with a multiple-choice question outlining decision-making factors for or against participating in the CiFi PV project. They were asked to choose a maximum of three factors that informed their decision. Participants also had the opportunity to add factors via a textbox. The different factors for or against participation were informed by former research [17,37] and are outlined in the results section at Section 4.1. Next, respondents rated the motivational attributes associated with CiFi PV project participation (covariate).

As a manipulation check, respondents were then asked to indicate which project characteristics their CiFi PV offer had displayed. We used a separate question for every treatment, providing a total of three answer options (e.g., “school building,” “petrol station,” and “carpentry workshop” for rooftop partner).

Finally, respondents were asked about their experience with CiFi PV projects, their liquid savings, their perception of the energy crisis, and their living situation (homeowner, tenancy, cooperative). We used these variables as exploratory covariates.

3.1.3. Data collection and analysis

Data collection took place between September and October 2022 using Qualtrics. A representative sample of the Swiss population was surveyed in collaboration with a Swiss market research institute ($N = 807$). Quotas were based on age, education, gender, income, linguistic region, living area and political orientation. A total of 807 completed questionnaires were evaluated. The average response time was around 10 min.

In the first step, we descriptively analyzed the data to answer RQ1a and 1b regarding the respondent's willingness to invest and the reasons for their decision. In the second step, we analyzed the experimental data to answer our RQ2 and hypotheses 1 to 4 regarding the influence of project characteristics on the perceived project attractiveness. To do so, we performed an Analysis of Covariance (ANCOVA) using the statistical software SPSS. We measured the influence of the project characteristics (provider, minimal investment sum, pay-out model, rooftop partner; independent variables) and covariates on the perceived attractiveness of the project (dependent variable). Covariates included standard socio-demographic variables and additional variables such as living situation, liquid savings, CiFi PV experience, energy crisis perception, and motivational attributes. Furthermore, we conducted a manipulation check based on a chi-square test of independence using SPSS.

3.1.4. Sample description

Males and females were represented equally, with a median age of 47. 27 % were highly educated with a university degree, 66 % had finished baccalaureate school or an apprenticeship, and 7 % had obtained no educational qualification or only a basic educational qualification. 75 % of the respondents resided in the Swiss-German-speaking area and 25 % in the French-speaking area of Switzerland (linguistic region). 60 % lived in a city or its surroundings, and 40 % in rural areas (living area). Approximately 50 % were homeowners, 48 % were tenants, and 2.5 % were cooperative housing members (living situation). Around 16 % indicated a monthly income below CHF 4500, 36 %

between CHF 4501 and 9000 and 45 % above CHF 9000. We also measured the respondents' financial situation by accounting for their liquid savings. 22 % had no liquid savings at the time of the study, around 25 % of the respondents had savings below CHF 5000, 22 % savings between CHF 5001 and 20,000, and 16 % had savings between CHF 20,001 and 100,000 CHF. Around 8 % of the respondents had more than CHF 100,000 in liquid savings at their disposal, and around 6 % chose not to share this information. Politically, 19 % were affiliated with the right-wing party SVP, 20 % with the left-wing party SP, 22 % with the liberal party FDP, 10 % with the green party Grüne, 9.5 % with the green-liberal party GLP and 12 % with the political center. Regarding age, education, gender, income, living area, linguistic region, and political orientation, the sample can be considered representative of the current population of Switzerland (see Table 4 for comparison).

3.2. Results

The manipulation check indicated effective manipulation across the four varying project characteristics. Chi-Square test of independence yielded significant relations between the effective treatment and the

Table 4
Sample characteristics, compared to respective characteristics of the population of Switzerland.

Characteristic	Sample (N = 807)	Switzerland
Age	M = 46 years, SD = 16.6 years	Year 2022 [54]: 42.8 years
Gender	- Female: n = 402 (49.8 %) - Male: n = 405 (50.2 %)	Year 2022 [55]: - Female: 51 % - Male: 49.7 %
Education	- Compulsory school: n = 100 (12.4 %) - Secondary education (e.g., vocational education): n = 487 (60.3 %) - Tertiary education (Bachelor or Master degree, PhD): n = 220 (27.3 %)	Year 2022 [56]: - Compulsory school: 19.4 % - Secondary education (e.g., vocational education): 44.4 % - Tertiary education (Bachelor or Master degree, PhD): 36.2 %
Income	- Below 6'000 CHF: n = 230 (28.5 %) - 6'001-9'000 CHF: n = 186 (23 %) - 9'001-12'000 CHF: n = 148 (18.3 %) - Above 12'000 CHF: n = 212 (26.3 %)	Year 2022 [57] - Up to CHF 6'000: 30 % - 6'001 to 9'000: 25 % - 9'001 to 12'000 CHF: 19 % - Above 12'001 CHF: 27 %
Living area	- City/agglomeration: n = 482 (59.7 %) - Rural: n = 325 (40.3 %)	Year 2023 [58]: - City/agglomeration: 63 % - Rural: 37 %
Linguistic region	- German: n = 606 (75.1 %) - French: n = 201 (24.9 %) - Italian excluded	Year 2024 [59]: - German: 62 % - French: 23 %
Political orientation	- SVP (right-wing): n = 1152 (18.8 %) - SP (left-wing): n = 162 (20.1 %) - FDP (liberals): n = 176 (21.8 %) - Mitte (middle): n = 98 (12.1 %) - GLP (green liberals): n = 77 (9.5 %) - Grüne (greens): n = 80 (9.9 %) - Other party: n = 62 (7.7 %)	Year 2023 [60]: - SVP (right-wing): 27.9 % - SP (left-wing): 18.3 % - FDP (liberals): 14.3 % - Mitte (middle): 14.1 % - GLP (green liberals): 7.6 % - Grüne (greens): 9.8 % - Other party: 0.4 %

manipulation check questions: Provider $X^2(1, N = 807) = 595.5, p \leq 0.001$; Minimum investment sum $X^2(1, N = 807) = 749.4, p \leq 0.001$; Pay-out model $X^2(1, N = 807) = 665, p \leq 0.001$, and Rooftop partner $X^2(1, N = 807) = 737.4, p \leq 0.001$.

3.2.1. CiFi PV expansion potential and decision factors

We analyzed immediate willingness to invest in a CiFi PV project to estimate its expansion potential across the broader population (RQ1a). We found that across all experimental conditions, 59 % of the respondents were willing to invest, indicating a high adoption rate among potential investors.

Regarding the factors that influenced the respondents' decision (RQ1b), we found that among those who chose to invest in CiFi PV (N = 478), 62 % did so to promote renewables and 56 % to promote photovoltaics (see Fig. 2). The desire to promote independent energy production also influenced the adoption of CiFi PV among 45 % of the respondents. The attractiveness of the return, the trustworthiness of the provider, and the desire to promote a tangible project were of minor importance to the respondents. Additional answer options highlighted the fact that a re-sell option is included in the project.

Among the respondents who chose not to invest in the CiFi PV project (N = 329), 47 % selected uncertainty about the provider's trustworthiness. This was followed by a lack of financial means (selected by 35 %). Regionality and the fact that the CiFi PV plant was not located in a nearby region known to the respondents played a role in declining the investment opportunity for around a third of the respondents (see Fig. 3). Among the additional answer options, 5 % of the sample said they had already invested in a private installation or a CiFi PV project. 2 % indicated that they would prefer direct electricity consumption, either privately or in the context of a community energy project, as well as the lengthy project duration and being too old. Other factors were uncertainty regarding the efficiency ratio, the potential risks, the desire to take more time to reflect on the offer and compare it with others, and criticism of private investment for solar power diffusion.

3.2.2. Influence of project characteristics on CiFi PV project attractiveness

We analyzed the influence of project characteristics on the perceived project's attractiveness (RQ2) and did not observe any significant main effects of project characteristics on the dependent variable ($F_{\text{provider}}(1, 710) = 1.42, p = .286, \eta_p^2 = 0.002, F_{\text{investment sum}}(1, 710) = 0.048, p = .826, \eta_p^2 = 0.000, F_{\text{pay-out model}}(1, 710) = 0.307, p = .580, \eta_p^2 = 0.000$ and $F_{\text{rooftop partner}}(1, 710) = 0.358, p = .550, \eta_p^2 = 0.000$).

The overall interaction effects of the four project characteristics on

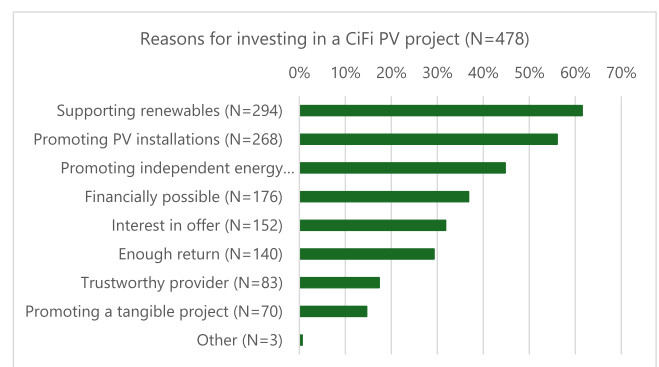


Fig. 2. Reasons for investing in a CiFi PV project. Respondents chose up to three reasons. Only respondents willing to invest answered this question; N = 478.

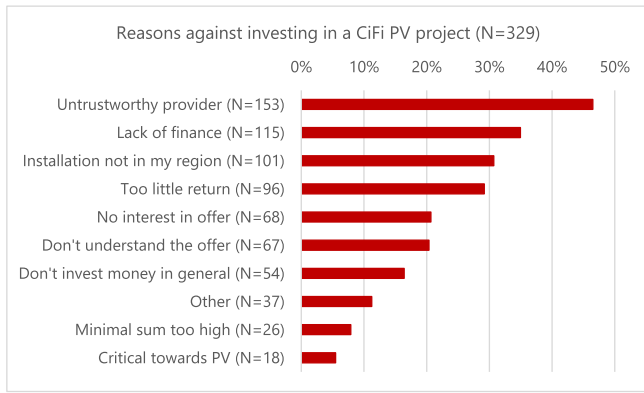


Fig. 3. Reasons against investing in a CiFi PV project. Respondents chose up to three reasons. Only respondents not willing to invest answered this question; N = 329.

the perceived attractiveness of the project are also non-significant ($F(1, 710) = 0.59, p = .442, \eta_p^2 = 0.001$). Looking at the estimated marginal effects of the treatments, we find minor variations between 4.7 and 4.8 on a scale from 1 to 7 (see Fig. 4 and Table 5). Thus, we reject H1 to H4.

Sociodemographic covariates did not yield significant results. The additional covariates CiFi PV experience, perception of energy crisis, and motivational attributes showed the following descriptive results: Respondents had limited experience with CiFi PV, as only 4.6 % had previously invested in one or multiple CiFi projects.³ Regarding the respondent's perception of a potential energy crisis, the sample yielded a mean of 2.8 on a 1 to 5-point Likert scale. This indicates that at the time of the experiment most respondents did not appear to be particularly worried about an energy crisis. Motivational attributes were distributed as follows: financial ($M = 3.26, SD = 0.84$), symbolic ($M = 2.54, SD = 0.95$), and societal impact ($M = 3.8, SD = 0.76$) on a 1 to 5-point Likert scale.

Among these additional covariates, financial and societal impact motivational attributes were significantly correlated with the project's attractiveness: financial attributes ($F(1, 710) = 66.98, p < .001, \eta_p^2 = 0.086$) and societal impact attributes ($F(1, 710) = 113.78, p < .001, \eta_p^2$

Table 5

Overview of estimated marginal means and standard deviations across the experimental treatments.

Project characteristic	Levels	Estimated marginal mean	Standard deviation
Provider	Company	4.78	0.059
	Cooperative	4.69	0.059
Investment sum	CHF 100	4.74	0.058
	CHF 750	4.72	0.058
Pay-out model	Lending	4.71	0.058
	Investment	4.75	0.058
Rooftop partner	Petrol station	4.71	0.059
	School	4.76	0.058

= 0.138). Participants scoring high on these motivational attributes thus perceived CiFi projects as more attractive, and conversely, participants scoring lower on these attributes perceived them as less attractive.

4. Experiment 2: the role of motivational project framing

4.1. Method and experimental design

We conducted an online vignette study ($N = 512$) to answer our third research question regarding the influence of motivational frames on a CiFi PV project's attractiveness. The CiFi PV project and its characteristics were kept constant across all the respondents. We chose project characteristics with the best results in the manipulation check of the first experiment, only adjusting the minimal investment sum slightly to reflect a less extreme distribution better corresponding to actual CiFi PV projects in the market. This led to a CiFi PV offer with the following project characteristics: commercial provider, minimum investment sum of 500 CHF, equity pay-out model, and a school building as rooftop partner.

The different frames used were informed by existing literature (see Section 2.3 for details) and by results from the first experiment. The first experiment showed that motivational factors significantly impact the perceived attractiveness of the projects and thus informed our H5, which indicates that motivational emphasis frames may improve a project's attractiveness. More specifically, the results showed that the presence of

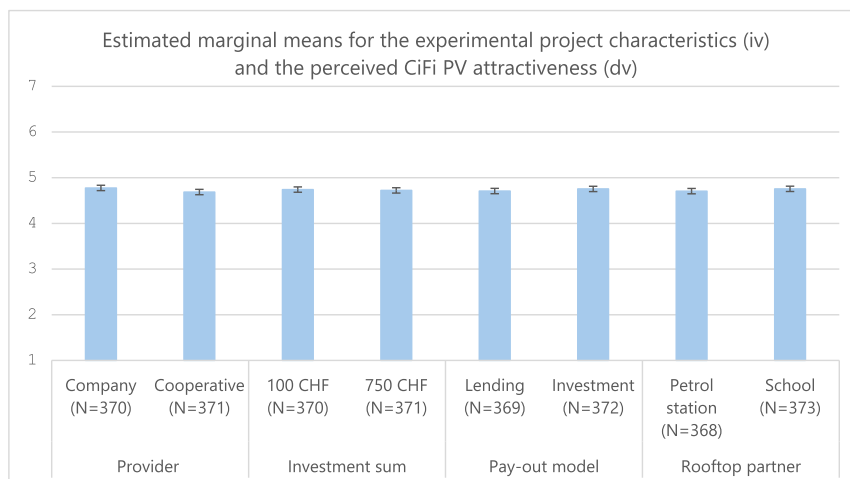


Fig. 4. Estimated marginal means for the project characteristics and the perceived project attractiveness. Error bars represent standard deviations.

³ We did not ask respondents whether they had previously heard of CiFi PV, as the phenomenon can be described in many different terms and is hard to narrow down to a single term.

Table 6

Overview of the motivational frames used in the experiment and the corresponding motivational sentence. Translated from the originals in German/French.

Motivational frame	Motivational phrase
Environment	Do something for the environment and opt for renewable energy!
Finance	Invest your money safely and profitably!
Energy independence	Promote our energy independence!
Local value creation	Support local businesses and organizations!
Civil society engagement	Set an example!
Tangibility	Make a concrete project possible!
Impact investment (combined frame)	- Gain attractive returns - Enable a concrete project - Create ecological and local added value
Neutral (control group)	Your participation in a solar plant

financial, environmental, and local value creation motivational attributes in evaluating CiFi PV participation increases the project's attractiveness. This, in turn, confirmed our previously established H6 outlining these three motivational factors as potentially more relevant than other motivations identified in the literature (see Section 2.3). In total, we used seven motivational frames, one combined motivational frame, and a neutral control frame (see Table 6). As for the previous experiment, the experimental design was validated by actual Swiss CiFi PV project developers to ensure that it conveyed realistic, clear, and motivating messages.

Table 6 presents an overview of the different motivational frames and the corresponding motivational sentence in the experiment (translated from German/French). Respondents were randomly assigned to one of the eight conditions (between-subjects design). Each frame was displayed in two consecutive forms: first, as a separate text box describing each of the main benefits of CiFi PV projects (see Fig. 5 for an example); second, as a motivational phrase at the top of the specific experimental CiFi PV project (see Table 6 and Appendix A1/A2 for an overview and example).

4.1.1. Experimental design

4.1.1.1. Independent variable. We used a nominal variable regrouping the different frames displayed as the independent variable. This included eight categories, each corresponding to one motivational frame (see Table 6 for an overview of the frames).

4.1.1.2. Dependent variable. As in the first experiment, we used the perceived attractiveness of the displayed CiFi PV project as our dependent variable based on a three-item scale. Respondents could answer on a Likert scale from 1 to 7 (1 = "I completely disagree", 7 = "I completely agree"). We conducted a reliability analysis, yielding an excellent score of Cronbach's $\alpha = 0.9$. In addition, we asked respondents to rate CiFi PV attractiveness in general using the same three-item scale; this yielded a Cronbach's $\alpha = 0.85$. This variable was displayed after introducing the motivational textbox but before the display of the specific project offer. We included this variable to control for the possible effect of project characteristics. We did not find substantial differences in the variance and distribution when comparing the two attractiveness scales. Consequently, we only used the project's attractiveness scale as the dependent variable for the subsequent ANCOVA analysis, following the same

Main advantages:

Citizen-financed solar projects have a positive impact on the environment: they contribute to low-carbon and renewable energy production.

Fig. 5. Example of the environment motivational frame in the treatment text box regarding main advantages of CiFi PV projects.

procedure as for the first experiment.

4.1.1.3. Covariates. We used most of the covariates from the first experiment (e.g., age, gender, education, income, political orientation, linguistic region (Swiss-German/French), living area (rural or city/agglomeration), and living situation (homeowner, tenancy, cooperative)). We also included the additional covariates: energy crisis perception (three-item scale), experience with CiFi PV, and liquid savings (see Section 3.1.1 for details).

Motivational attributes were excluded as covariates, as we hypothesized that an effective motivational treatment based on motivational attributes would result in significant correlations between the frames and the corresponding motivational factors. Instead of the motivational attributes scale, we introduced a 5-point Likert scale about life principles in line with that of Steg and colleagues [61,62] with answer options for egoistic, hedonic, altruistic, and biospheric values. We chose to include this as an additional covariate, as literature has shown that besides motivational attributes, underlying values can play a role in the PV adoption process [17,30].

4.1.2. Survey flow and descriptives

Respondents were first presented with a short introduction to CiFi PV models. Next, they were shown the first treatment element, which consisted of the motivational textbox that outlined specific benefits of CiFi PV depending on the frame (see Fig. 5). Respondents were then asked to rate CiFi PV attractiveness in general (without seeing a particular project offer). Next, they were introduced to a specific offer (kept constant across the sample), including a motivational sentence (in line with the randomly assigned frame treatment), and asked to study it carefully. Respondents then rated their willingness to invest with a binary variable ("Yes, probably"/"No, probably not") and were asked to indicate their perception of the project's attractiveness (dependent variable in the ANCOVA model).

Due to time constraints, we did not integrate a question regarding the factors for and against investing in the project (compared with the first experiment). Respondents were asked to rate a question regarding their life-guiding principles. Finally, respondents were asked about their experience with CiFi PV projects, liquid savings, perception of the energy crisis, and living situation (homeowner, tenancy, cooperative).

4.1.3. Data collection and analysis

Data collection took place between October and November 2022 using Qualtrics. For the first experiment, a representative sample was surveyed in collaboration with a Swiss market research institute. Respondents in the first experiment were excluded from this sampling process. The same quotas of the first experiment were used: age, education, gender, income, linguistic region, living area, and political orientation. A total of 512 completed questionnaires were evaluated. The average response time was around 7 min.

As in the first experiment, we analyzed the binary variable on the willingness to invest descriptively to address our initial research question. After that, we conducted an Analysis of Covariance (ANCOVA) in SPSS, using the project's attractiveness scale as the dependent variable, to answer our second research question.

4.1.4. Sample description

The second experiment's sample was highly similar to that of the first experiment. Males and females were represented equally, with a median age of 45. 38 % were highly educated with a university degree, 63 % had finished baccalaureate school or an apprenticeship, and 7 % had obtained no educational qualification or only a basic educational qualification. 75 % of the respondents resided in the Swiss-German-speaking area and 25 % in the French-speaking area of Switzerland (linguistic region). 65 % lived in a city or its surroundings, and 35 % in rural areas (living area). Approximately 48 % were homeowners, 48 % were

tenants, and 2.5 % were cooperative housing members (living situation). Around 14 % reported a monthly income below CHF 4500, 38 % between CHF 4501 and 9000, and 44 % above CHF 9000. 25 % of the sample had no liquid savings at the time of the study. Around 26 % had savings below CHF 5000 CHF, 23 % between CHF 5001 and 20,000, and 14 % between CHF 20,001 and 100,000. Around 8 % of the respondents had over CHF 100,000 in liquid savings at their disposal, and around 5 % chose not to share this information. Politically, 20 % were affiliated with the right-wing party SVP, 19 % with the left-wing party SP, 21 % with the liberal party FDP, 11 % with the green party Grüne, 11 % with the green-liberal party GLP and 11 % with the political center. Regarding age, education, gender, income, living area, linguistic region, and political orientation, the sample can be considered representative of the current population of Switzerland (see Table 7 for comparison).

4.2. Results

4.2.1. CiFi PV expansion potential and decision factors

Across the second experimental study sample, 56 % of the respondents were willing to invest in the CiFi PV project. These results indicate a relatively high adoption rate among potential investors and thus confirm the results of the first experiment in another sample representative of the current population of Switzerland.

Table 7

Sample characteristics, compared to respective characteristics of the population of Switzerland.

Characteristic	Sample (N = 512)	Switzerland
Age	M = 45.9 years, SD = 16.9 years	Year 2022 [54]: - 42.8 years
Gender	- Female: n = 256 (50 %) - Male: n = 256 (50 %)	Year 2022 [55]: - Female: 51 % - Male: 49.7 %
Education	- Compulsory school: n = 54 (10.5 %) - Secondary education (e.g., vocational education): n = 303 (59.2 %) - Tertiary education (Bachelor or Master degree, PhD): n = 155 (30.3 %)	Year 2022 [56]: - Compulsory school: 19.4 % - Secondary education (e.g., vocational education): 44.4 % - Tertiary education (Bachelor or Master degree, PhD): 36.2 %
Income	- Below 6'000 CHF: n = 148 (28.9 %) - 6'001–9'000 CHF: n = 122 (23.8 %) - 9'001–12'000 CHF: n = 94 (18.4 %) - Above 12'000 CHF: n = 129 (25.2 %)	Year 2022 [57] - Up to CHF 6'000: 30 % - 6'001 to 9'000: 25 % - 9'001 to 12'000 CHF: 19 % - Above 12'001 CHF: 27 %
Living area	- City/agglomeration: n = 334 (65.2 %) - Rural: n = 178 (34.8 %)	Year 2023 [58]: - City/agglomeration: 63 % - Rural: 37 %
Linguistic region	- German: n = 386 (75.4 %) - French: n = 126 (24.6 %) - Italian excluded	Year 2024 [59] - German: 62 % - French: 23 %
Political orientation	- SVP (right-wing): n = 102 (19.9 %) - SP (left-wing): n = 95 (18.6 %) - FDP (liberals): n = 197 (20.9 %) - Mitte (middle): n = 58 (58 %) - GLP (green liberals): n = 56 (10.9 %) - Grüne (greens): n = 55 (10.7 %) - Other party: n = 39 (7.6 %)	Year 2023 [60]: - SVP (right-wing): 27.9 % - SP (left-wing): 18.3 % - FDP (liberals): 14.3 % - Mitte (middle): 14.1 % - GLP (green liberals): 7.6 % - Grüne (greens): 9.8 % - Other party: 0.4 %

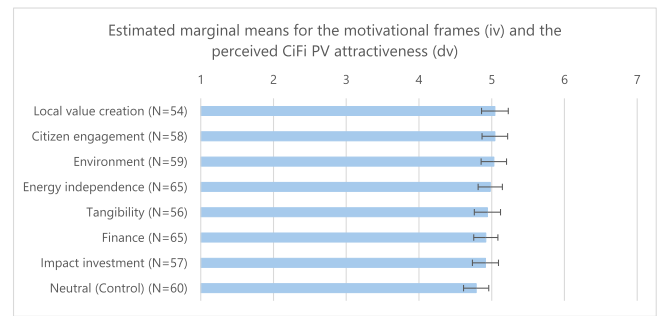


Fig. 6. Estimated marginal means for the motivational frames and the perceived project attractiveness. Error bars represent standard deviations.

Table 8

Overview of estimated marginal means and standard deviations across the experimental treatments.

Motivational frame	Estimated marginal mean	Standard deviation
Local value creation	5.04	0.184
Civic engagement	5.04	0.176
Environment	5.03	0.175
Energy independence	4.98	0.167
Tangibility	4.94	0.180
Finance	4.92	0.166
Impact investment	4.91	0.179
Neutral (control)	4.79	0.173

4.2.2. Influence of motivational frames on CiFi PV project attractiveness

Regarding the influence of motivational frames on the project's attractiveness, our results show no significant main effects on the dependent variable ($F(1, 450) = 0.245, p = .974, \eta_p^2 = 0.004$). Looking at the estimated marginal effects of the treatments, we find minor variations between 4.8 and 5 on a scale from 1 to 7 (see Fig. 6 and Table 8). Thus, we reject both H5 and H6.

Sociodemographic covariates did not yield significant results. The additional covariates CiFi PV experience, perception of energy crisis, and life-guiding principles exhibit the following descriptive results: Respondents had limited experience with CiFi PV, as only 4.1 % had previously invested in one or multiple CiFi projects.⁴ Regarding the respondent's perception of a potential energy crisis, the sample yielded a mean of 2.6 on a 1 to 5-point Likert scale. This indicates that, as in the first experiment, most respondents did not appear to be particularly worried about an energy crisis. Life-guiding principles were distributed as follows: egoistic ($M = 2.87, SD = 0.79$), hedonic ($M = 3.82, SD = 0.75$), altruistic ($M = 4.14, SD = 0.69$), and biospheric ($M = 4.25, SD = 0.7$) on a 1 to 5-point Likert scale.

The project's perceived attractiveness is significantly affected by three additional covariates. Among the four life-guiding principles, both altruistic values ($F(1, 450) = 7.98, p < .01, \eta_p^2 = 0.0017$) and biospheric values ($F(1, 450) = 20.21, p < .001, \eta_p^2 = 0.043$) have a significant effect. This means that individuals who are guided more by altruistic or biospheric life principles perceive the CiFi PV project as more attractive. Moreover, the perception of an energy crisis also significantly influences the project's attractiveness ($F(1, 450) = 9.036, p < .01, \eta_p^2 = 0.020$). In other words, individuals who are more concerned about a potential energy crisis are more likely to perceive the CiFi PV project as attractive.

⁴ We did not ask respondents whether they had previously heard of CiFi PV, as the phenomenon can be described in many different terms and is hard to narrow down to a single term.

5. Discussion

5.1. High potential for CiFi PV diffusion

Our first research question sought to grasp the diffusion potential of CiFi PV among the broader Swiss population by accounting for the willingness to invest in a specific project across two representative samples. Our results show that more than half of the respondents were interested in investing in a CiFi PV project. This means that CiFi PV projects have a high potential for adoption among the broader population, underscoring their capacity to engage various kinds of people [5,23]. Interestingly, tenants and homeowners are equally interested in CiFi PV projects and therefore both represent target groups for project developers. This confirms findings from previous studies [5,63], though it contrasts with the widespread perception of project developers that these projects mainly attract tenants [34,37]. While a rounded-up 60 % of the respondents would potentially invest, we find that across the two samples, 95 % have yet to gain experience with such projects.

This may be due to two aspects. First, as stated in the introduction to this paper, CiFi PV currently represents a niche within the broader PV market. With around 50 projects in Switzerland (in 2022) [5], the respondents' lack of experience probably stems from the limited number of projects. In the case of wind energy co-financed projects, for example, demand for wind power investment opportunities has been found to exceed supply [14]. This has also been found to be the case for CiFi PV projects in Switzerland [17]. Second, Switzerland has no specific policy framework promoting CiFi PV project development [5]. Project developers have been observed to commit to co-financing renewable energy projects not primarily for financial concerns but rather to improve social acceptance of the project [14,17], foster inclusivity, and attain policy goals [17]. However, the development of such projects requires regulatory frameworks that minimize complexity and transaction costs and decrease exposure to electricity volatility [14]. The recently adopted Federal Act on a Secure Electricity Supply from Renewable Energy Sources (2024) will foster PV development and bears the potential to particularly promote the expansion of CiFi PV projects through financial incentives and the possibility to create local electricity communities.

We analyzed factors for and against an intended investment in the first experiment. We found that promoting solar power diffusion and supporting renewable energy generation were the most commonly reported reasons for investment. These aspects represent the essence of CiFi PV projects and align with findings from previous studies on CiFi PV participation [5,10,13]. The most cited factor against an investment was the uncertainty regarding the trustworthiness of the project developer. This result suggests that individuals who are more skeptical about the offer may analyze it in greater detail, realizing that they do not know the project developer. While respondents were provided with either a company or a cooperative named "SunEnergy" as the project developer, neither exists. Trust has been found to be an important driver in CiFi PV adoption [39] and appears to be especially relevant for reaching individuals who are not yet convinced of such models. The second-most cited factor was lack of finance, which was given by approximately one-third of the respondents unwilling to invest. This highlights a risk, albeit a seemingly small one in Switzerland, of excluding households or individuals from low-income groups in co-financed projects [5,64,65].

5.2. Participating regardless: CiFi PV seems to be simply a good thing to do

Both experiments showed no significant effects of project characteristics and motivational framing on the perceived attractiveness of a CiFi PV project. While the intended adoption rate is relatively high and indicates a potential for CiFi PV diffusion across the broader population, we find that it is not the details of the project and its communicative embedment that matter. Consequently, we reject our hypotheses.

The pay-out model has been found to influence the decision-making

process of CiFi PV adopters regarding monetary versus direct solar power compensation [30]. However, lending or equity-based return schemes and the minimum investment sums do not yield significant results. This echoes the findings by Salm and colleagues [66], showing that retail investors primarily rely on their gut feeling and simple calculations regarding payback time. In contrast to a monetary return, receiving solar power produced is more tangible than differentiating between lending and equity. Salm and colleagues further found that developers such as municipal utilities or energy cooperatives were preferred over financial institutions. We hypothesized that utilities were preferred over energy cooperatives as they provide more financial security [20] and are considered locally rooted [16,42]. However, results indicate that both forms of organizations are accepted and that the differentiation between a market- and grassroots organization, as proposed in the literature [20,35], may need to be used cautiously. While energy utilities are considered market-oriented, as they operate as firms with top-down decision-making and generate commercial income, they do not appear to be perceived equally to financial institutions. Instead, they are perceived similarly to energy cooperatives, which are regarded as grassroots organizations [35]. Finally, though qualitative research has found some individuals motivated by personally valued rooftop partners, such as schools [17], we did not find any influence compared to an installation on top of a petrol station. This may indicate that using existing infrastructure may be the primary concern rather than the specific rooftop owner.

Regarding participation motivations, the first experiment showed that CiFi PV projects appeal to individuals who associate them with financial and societal benefits such as environmental protection, local value creation, and energy independence. While Sierro and Blumer [5] used a four-dimensional motivational attribute scale, tested in the context of CiFi PV adoption of individuals with prior experience, our principle component analysis yielded a three-dimensional solution, with environmental and local value creation loading on the same factor, including our newly added items regarding energy independence attributes. We summarized these motivational attributes under the category "societal impact" attributes. The difference between the two scales and their component loadings may stem from Sierro and Blumer testing this scale with actual CiFi PV participants. In contrast, we used it with potential CiFi PV investors, of which 95 % had no prior experience with CiFi PV projects. The fact that we integrated three additional items on energy independence attributes may also have influenced the distribution of the component loadings. All in all, this study confirms the findings of previous research, i.e., that financial [5,20] and societal impact motivational attributes, comprising elements such as environmental protection [5,22], local value creation [5], and energy independence [10], significantly influence the attractiveness of a CiFi PV project and, potentially, its adoption.

While such motivational attributes significantly impacted perceived attractiveness in our first experiment, translating them into frames triggering motivational aspects did not yield the same results. Even with carefully selected communicative framings to differentiate underlying motivations, highlighted with a motivational phrase and a textbox outlining the respective benefits for each frame, we did not observe a significant influence on the perceived project attractiveness, and the observed willingness to invest remained similar across the two experiments.

There are a number of possible reasons for this. First, it could be due to a ceiling effect, meaning that projects aiming to trigger specific underlying motivations do not necessarily attract substantially more individuals. It has been noted in the literature that "*To be motivated means to be moved to do something.*" [67, p.54]. In other words, motivational frames may not necessarily lead to further pushing of a specific behavior or intended action if people are already motivated.

Second, as shown in the second experiment, altruistic and biospheric values significantly influenced the perceived project attractiveness, while the motivational frames did not. This is in line with previous

research showing that intrinsic motivations, which are related to personal values, influence the perception of a project [30]. Intrinsic motivations, in contrast to extrinsic motivations, are based on inherent satisfaction from doing a specific action or activity [67] and on curiosity [68] instead of a separable consequence pushed for by pressures or rewards [30]. Comparing the two experiments with each other, we argue that the first experiment grasped the intrinsic motivations of individuals through the measurement of perceived motivational attributes of a CiFi PV project. The second experiment operationalized these motivational attributes as communicative frames and functioned as an extrinsic motivator. While extrinsic motivations, such as rewards, benefits, or pressures, may influence pro-environmental behavior [69], outlining specific benefits for CiFi PV does not activate intrinsic motivations, and consequently does not increase the individually perceived attractiveness of such a project.

In line with this, our first experiment indicated that one of the main reasons for investing in the project was the desire to promote solar power and renewable energy production. This represents the essence of a CiFi PV project, as its practical impact is creating a new, functional solar power plant generating renewable energy. In other words, the purpose and palpable outcome of a CiFi PV project seem sufficiently attractive to appeal to the broader population. CiFi PV projects are generally perceived as a positive initiative by a wide range of people, regardless of their socio-demographic backgrounds or specific external motivations. Based on these findings, we believe CiFi PV projects can attract diverse individuals because intrinsic motivations primarily drive their appeal. However, measuring intrinsic motivations can be difficult because they are not readily observable [70]. A recent study [17] identified a wide range of motivations behind actual CiFi PV investments, indicating that CiFi PV projects encompass various aspects that resonate with an individual's intrinsic motivations at different levels. Therefore, we propose that CiFi PV projects can attract individuals with diverse socio-demographic backgrounds and external motivations simply because people can identify with these projects and want to support them.

Meanwhile, we found that the perception of a potential energy crisis significantly impacts perceived project attractiveness, but only in the case of the second experiment. We attribute this to the timing of the data collection. The first experiment occurred in September and early October 2022; the second was in late October and November of the same year. In Switzerland, November is considered the entry point into the winter months. Over the summer months, headlines across a wide range of newspapers and official news channels highlighted the risk of an energy shortage during the coming winter months, with headlines such as: “*We are racing towards a blackout—and nobody is getting upset*” [71], “*How Switzerland intends to tackle the energy crisis this winter*” [72], “*Experts warn: Switzerland faces an electricity shortage in the coming winter*” [73], etc. While the survey respondents were not particularly concerned with a potential energy crisis, the timing of the second experiment and the omnipresence of such news articles may explain why the individual perception of a possible energy crisis significantly impacted project attractiveness.

5.3. Limitations and future research

The study is based on two online experiments designed to detect large to medium-sized effect sizes. Although both designs could be powered up to detect even smaller effect sizes, the estimated means do not suggest clear tendencies that could be explored further. Additionally, our experimental designs are strongly inspired by actual CiFi PV project offers and may depict tendencies for real-world decisions more accurately than experiments with less realistic designs. However, uncertainty about the provider's trustworthiness has been found to be the main reason for a low willingness to invest in CiFi PV. Though our experimental design is highly realistic, we did not provide existing providers to the respondents. To understand how trust toward the

provider influences individuals' adoption behavior, case studies on specific projects and developers may be promising.

Concerning motivational framing, a recent literature review by Ropret Homar and Knežević Cvelbar [50] shows that loss framing has been found to be more effective in stimulating green intentions and behaviors. In our experiment, we used positively connotated emphasis frames as motivational triggers. Future studies could test whether framing motivational attributes of a CiFi PV project in terms of potential losses would make a difference. However, practically translating benefits such as investment security or environmental protection into loss frames to communicatively embed a CiFi PV project may be challenging.

Our results suggest that the details of a CiFi PV project, such as specific project characteristics and motivational framing, do not matter. Instead, CiFi PV projects are highly attractive to the broader population as they promote solar power diffusion and resonate with various motivations, from gaining individual financial benefits to collective local value creation and environmental protection benefits. For project developers, this means that they may not have to worry about the detailed project design, but rather that they should increase the offer for CiFi PV projects. This raises new research questions on what promotes or hinders CiFi PV project development, what framework conditions are conducive to such projects, and what motivations underlie the project development from a provider perspective. Knauf and Wüstenhagen [14] focused on the project developers' perspective in a recent study on crowdsourcing social acceptance in the context of wind power. Future research on CiFi PV should focus on this perspective to provide a more holistic picture of its diffusion and potential to contribute to the energy transition.

Simultaneously, this study has not accounted for any potential biases influencing willingness to invest, such as heuristics or social norms. A recent study by Sierro and Blumer [17] has shown that some CiFi PV participants imagine that they consume the electricity produced directly and reduce energy efficiency losses by avoiding long-distance transport. This is an example of a cognitive bias influencing investment decisions, which is not necessarily factually correct. Other studies have found that individuals have lay theories regarding investments and follow gut instincts and social norms rather than rational win/loss calculations [66,74]. Future studies may want to consider the influence of such biases and analyze their influence on the willingness to invest.

Finally, this study measures intentions rather than actual investment decisions. Consequently, even though our results suggest that CiFi PV projects in their current form bear a considerable diffusion potential across the broader population, this may not necessarily translate into actual investment decisions [50]. Field experiments could shed light on this issue. However, evidence from CiFi PV projects in the Swiss market indicates that the demand is high, as project developers continue to succeed in raising the necessary funds rapidly with projects that sell out fast [37]. Again, the project developer's perspective appears promising for future research on CiFi PV projects and their diffusion potential.

6. Conclusion

Citizen-financed PV projects are considered inclusive and can close financial and social acceptance gaps in developing new, large-scale solar power plants [5,10,23,30]. Based on two online experiments, this study shows that CiFi PV projects have a strong diffusion potential because of their capacity to engage various kinds of individuals. Neither the project characteristics nor a communicative framing based on motivational attributes significantly affect the perceived attractiveness of CiFi PV projects. It seems that CiFi PV projects are perceived as a good and useful thing to do because of their purpose of enhancing solar power production, thereby presumably echoing an intrinsic motivation.

For practice, these findings indicate that the precise project configuration will probably have little effect on its attractiveness and adoption potential. Instead, project developers should concentrate on developing new projects, as CiFi PV projects have the potential to appeal to a broad audience. Both projects by energy cooperatives and utilities (i.e.,

grassroots and market-oriented developers) are attractive. In addition to tenants, developers should also market their projects to homeowners. It seems important that the general discourse regarding CiFi PV projects embeds them in the broader context of the energy transition, as individuals display motivations related to economic, environmental, and social sustainability aspects linked to this transition. Since CiFi PV projects are apparently largely unknown, project developers should enhance their projects' visibility through marketing campaigns and by broadening their project portfolio.

Creating the necessary frameworks conducive to such projects is essential to increase the number of CiFi PV projects and improve their visibility among the broader population. For policymakers, the findings highlight that market-oriented projects developed by energy utilities are similarly attractive to grassroots ones created by energy communities (i. e., cooperatives). Market-oriented projects are estimated to have a greater potential for expansion than grassroots projects [75]. However, existing regulatory frameworks at the European level currently promote only the development of community-led CiFi PV projects, excluding market-oriented ones [17,76]. To acknowledge the diversity of citizen-financed renewable energy projects, policymakers need to expand these supporting schemes. They may want to either enhance existing regulatory frameworks or introduce additional ones that specifically foster the development of market-oriented projects. Particularly in the event of an energy shortage, CiFi PV projects are perceived as desirable. With their focus on developing large-scale PV plants, they have the potential to contribute to a more resilient energy system and should be promoted accordingly.

Appendix A

A.1. Overview of the experimental treatments for the second experiment (N = 512). Translated into English (originals in German and French)

Frame	Main advantages	Motivational phrase
Environment	Citizen-financed solar projects have a positive impact on the environment: they contribute to low-carbon and renewable energy production.	Do something for the environment and opt for renewable energy!
Finance	Citizen-financed solar projects are attractive investments. They are low-risk and offer a higher return than a bank account.	Invest your money safely and profitably!
Energy independence	Citizen-financed solar projects promote Switzerland's energy independence by reducing the need to import electricity from abroad.	Promote our energy independence!
Local value creation	Citizen-financed solar projects promote local value creation: local installation companies benefit from orders, and roof owners benefit from cheap solar power.	Support local businesses and organizations!
Civil society engagement	Citizen-financed solar projects send a political and economic signal: the Swiss population wants a faster expansion of renewable energies.	Set an example!
Tangibility	Citizen-financed solar projects enable investment in specific projects: Where the money goes and what happens to it is clear from the outset.	Make a concrete project possible!
Impact investment (combined frame)	<ul style="list-style-type: none"> • Citizen-financed solar projects are attractive investments. They are low-risk and offer a higher return than a bank account. • They enable investment in specific projects: Where the money goes and what happens to it is clear from the outset. • They are positive for the environment: they contribute to low-carbon and renewable energy production. • They promote local value creation: local installation companies benefit from orders and roof owners benefit from cheap solar power. 	<ul style="list-style-type: none"> - Gain attractive returns - Enable a concrete project - Create ecological and local added value
Neutral (control group)	No text on main advantages ≥Directly to the offer	Your participation in a solar plant

CRedit authorship contribution statement

Fabienne Sierro: Writing – review & editing, Writing – original draft, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Corinne Moser:** Writing – review & editing, Validation, Supervision, Methodology, Formal analysis, Conceptualization.

Declaration of generative AI and AI-assisted technologies in the writing process

During the preparation of this work the authors used Grammarly and Chat GPT in order to improve reading flow and check grammar. After using this tool/service, the authors reviewed and edited the content as needed and take full responsibility for the content of the publication.

Declaration of competing interest

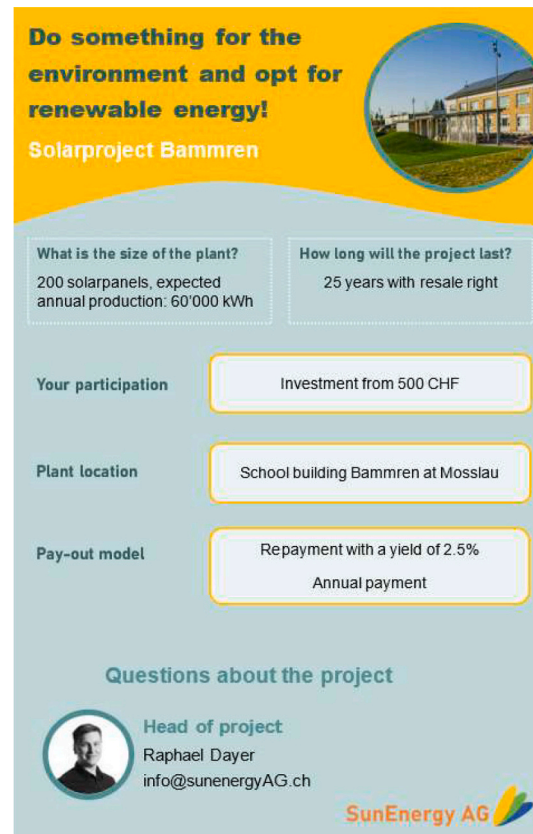
The authors declare that they have no known competing monetary interests or personal relationships that could have appeared to influence the work reported in this paper.

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A.2. CiFi PV offer example, including the motivational frame treatment “Environment” (second experiment). Translated into English (originals in German and French)

<p>Main advantages</p> <p>Citizen-financed solar projects have a positive impact on the environment: they contribute to low-carbon and renewable energy production.</p>



Do something for the environment and opt for renewable energy!
Solarproject Bammren

What is the size of the plant?
200 solarpanels, expected annual production: 60'000 kWh


How long will the project last?
25 years with resale right

Your participation Investment from 500 CHF

Plant location School building Bammren at Mosslau

Pay-out model Repayment with a yield of 2.5%
Annual payment

Questions about the project

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Data availability

Data will be made available on request.

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