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## The Consumption of Photovoltaic Energy Based on the Theory of Practice and Sociotechnical Transitions

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### Abstract

This paper seeks to advance the discussions involving the articulation between the theory of Sociotechnical Transitions and Practice Theory. The text tries to develop this articulation considering that it is possible to find in the literature notes that the Theory of Sociotechnical Transitions is a suitable partner to be articulated with the Theory of Practice. The proposition was tested in empirical research in which we sought to understand how consumption practices change from adopting photovoltaic energy consumption. The research is categorized as qualitative research. The study offers an interpretation of the object from the theoretical lens provided by Social Practice Theory and Sociotechnical Transitions, also known as Multilevel Perspective or “MLP.” In total, 24 interviews were executed, 7 with integrators, 7 with quasi-prosumers, and 10 with prosumers. To analyze the data, content analysis was used. The study's findings demonstrate that sociotechnical systems are reconfigured from the introduction of a new practice to accommodate this newly incorporated practice. Additionally, some of the pre-existing methods are modified during this accommodation process. It is also possible to conclude that the sociotechnical dimensions can be helpful in studies of phenomena that involve the transition of habits, routines, behavior patterns, and practices, as they provide a model of assumptions for sociotechnical change.

### Keywords

consumption, theory of practice, sociotechnical transitions, multilevel perspective, photovoltaic energy

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# **The Consumption of Photovoltaic Energy Based on the Theory of Practice and Sociotechnical Transitions**

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This paper seeks to advance the discussions involving the articulation between the theory of Sociotechnical Transitions and Practice Theory. The text tries to develop this articulation considering that it is possible to find in the literature notes that the Theory of Sociotechnical Transitions is a suitable partner to be articulated with the Theory of Practice. The proposition was tested in empirical research in which we sought to understand how consumption practices change from adopting photovoltaic energy consumption. The research is categorized as qualitative research. The study offers an interpretation of the object from the theoretical lens provided by Social Practice Theory and Sociotechnical Transitions, also known as Multilevel Perspective or “MLP.” In total, 24 interviews were executed, 7 with integrators, 7 with quasi-prosumers, and 10 with prosumers. To analyze the data, content analysis was used. The study's findings demonstrate that sociotechnical systems are reconfigured from the introduction of a new practice to accommodate this newly incorporated practice. Additionally, some of the pre-existing methods are modified during this accommodation process. It is also possible to conclude that the sociotechnical dimensions can be helpful in studies of phenomena that involve the transition of habits, routines, behavior patterns, and practices, as they provide a model of assumptions for sociotechnical change.

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## **Introduction**

Electrical infrastructure makes modern life possible. Its configuration and day-to-day operation depend on what people do at home and work. The infrastructures, as well as the daily lives of customers, shape one another. It is essential to examine the interdependence between infrastructure and everyday life practices and how they are constituted at different scales over time (Shove & Trentmann, 2018).

In 2015, the United Nations adopted the Sustainable Development Goals (SDGs) to balance social, economic, and environmental sustainability worldwide. We highlight herein SDG 7 – “Accessible and Clean Energy” – whose purpose is for everyone to access modern forms of sustainable, reliable, and low-cost energy.

Before this challenge, decarbonization, decentralization, and digitalization (the three Ds of energy) are the three main drivers of change that can affect energy infrastructure today and in the coming years. Decarbonization occurs through the generation of low-carbon energy, the use of renewable energy sources, and the improvement of efficiency in the generation, transport, and use of energy. Decentralization occurs through the increased participation of customers and demand, which requires a decentralized supply of energy, thus generating new needs, especially at the distribution level. Finally, digitalization arises from new solutions and

emerging technologies that lead to new business models based on digital paradigms (Di Silvestre et al., 2018).

Historically, conventional power generation was based on a centralized model. Thus, large generating plants (for example, hydroelectric and thermoelectric plants) are responsible for generating energy. In addition, large networks composed of transmission lines are responsible for conducting energy to areas where final consumers are located.

However, a new model emerges from the development of new technologies, in which the generation of energy occurs through small-scale installations located in the consumer units themselves or in places very close to consumers. Wolsink (2012) refers to this model as distributed generation in microgrids or DisGenMiGrids (according to the acronym used by the author).

According to Verbong et al. (2013), a decentralized generation structure is precisely the most striking difference in relation to the current energy system, as families and consumers have a new role: now they “cultivate” their own energy and, therefore, participate actively in the energy market, in which they supply their own demand. It is worth mentioning that in this new generation model, solar energy occupies a prominent position.

Solar energy has a prominent position as it is the most abundant alternative source of energy on our planet. Lewis and Nocera (2007) affirm that solar energy is undeniably (and by far) the greatest energy resource in potential terms. The sun supplies the earth in one hour the equivalent of all energy consumed by humanity in an entire year. Unfortunately, there is no technology available for all this potential solar energy to be properly harnessed. However, photovoltaic (PV) generation systems have shown important evolutions over the years, which have enabled the conversion of part of solar energy into electrical energy.

The Theory of Practice (TP) brings the energy consumer into the discussion and offers a useful approach to understanding consumer behavior (Halkier et al., 2011). This theoretical approach provides a broad framework of ideas and heuristic models for studies that aim to investigate electricity consumption (Galvin & Sunikka-Blank, 2016).

Nevertheless, TP as an approach is criticized for overemphasizing agency while underestimating structure (Sovacool & Hess, 2017; Warde, 2014). One way of mitigating the fragility attributed to TP is to combine it with an additional theoretical approach of complementary nature. The literature points to the “Theory of Sociotechnical Transitions” (TST) as a suitable partner to be articulated together with the TP (Sovacool & Hess, 2017; Warde, 2014). Warde (2014) describes that the partnership between the practical-theoretical approach and TST, in the development of consumer studies, is even more convenient when the latter is considered based on the Multilevel Perspective (MLP) developed by Geels (2002). It is worth mentioning that the combination between TP and TST presents itself as an appropriate alternative for the development of studies that aim to empirically explore new technologies and how they interact with consumer practices (McMeekin & Southerton, 2012).

The purpose of this empirical research is to understand how changes in the consumption of photovoltaic energy affected other spheres of household consumption based on the articulation between the Theory of Practice and the Theory of Sociotechnical Transitions.

Following Warde's (2014) suggestion, this research proposes the articulation between the theory of practice and the theory of sociotechnical transitions in the field of photovoltaic energy. The work of McMeekin and Southerton (2012), mentioned by Warde (2014) as an example of articulation between TP and TST, examines the importance of the processes involved in final consumption to better understand the prospective transitions towards a more sustainable model of society. By examining the tensions and the intersections between practice and MLP approaches applied to consumer studies, the authors conclude that there are three specific forms of interactions pertinent to future conceptual and empirical exploration, namely

the social relations of consumption, co-dependent changes in production and consumption, and technologies, practice, and consumption.

It is important to highlight that literature presents a few relevant studies that reconcile TP and TST. Gram-Hanssen (2010) analyzed residential heating habits and energy consumption from a practical-theoretical perspective, presented as a development within the sociotechnical approach. Crivits and Paredis (2013) assessed the role of consumption practices in the transition towards a sustainable food system. Jalas, Hyysalo, Heiskanen and Nissinen (2017) studied daily experimentation in the transition of energy practices. Amongst the international studies, we mentioned the work of Shove (2004), known as “Efficiency and Consumption: Technology and Practice,” in which the author illustrates how sociological theories on consumption, technology and practice can contribute to the formulation of environmental and energy policies. Moreover, the author makes use of insights stemming from Geels’ (2002) transition theory.

The present article was organized in four other sections, in addition to this introduction. The aim of the next topic is to bring insights of a theoretical nature about the articulation between the theory of practice and the theory of sociotechnical transitions. Subsequently, we present a section that provides information on the methodological procedures related to the field work. The section for data analysis and presentation demonstrates the main findings of the research, and, finally, the conclusions of the paper are presented.

## **Literature Review**

### **Articulating the Theory of Practice and the Theory of Sociotechnical Transitions**

The complexity brought about by the continuous debate on the structure-agency issue, which is to be found not only in social theories but also in philosophy, has led several scholars over the past few years to focus on the so-called social practice theories (Halkier et al., 2011). These practice theories have been, therefore, constituted to transcend and go beyond the structure-agency dualism, which is still present and dominant in sociological thought (Røpke, 2009; Warde, 2014). Thus, the Theory of Practice emerges as the result of efforts to break free from this historically established dualism (Røpke, 2009). By focusing on the action and on the social life, such theory seeks to overcome the debates on structure and agency and shows how the resources of social life are combined and interact in the practices (Hargreaves, 2008). Therefore, the theory of practice is understood as relational and seeks to understand and transcend the dualisms of structure and agency, determination, and voluntarism (Shove et al., 2012).

According to Halkier et al. (2011), the Theory of Practice can be quite useful to understand how changes in consumer behavior occur, however it has some limitations. Sovacool and Hess (2017) state that theories of social practice tend to overemphasize agency and underestimate structure. Furthermore, these theories often fail to adequately describe the broad systemic forces that affect technology. Warde (2014) emphasizes such fragility by pointing out that TP is more adequate to describe and analyze the details related to the use and consumption of goods than to properly elucidate the institutional or systemic conditions related to the existence of practices. Warde (2014) still argues that practice theories may need to be complemented with other structures, especially to capture macro or structural aspects of consumption, which reinforces the combination of Theory of Practice with the theory of sociotechnical transitions. Such combination is emphasized by the author through the example of the work of McMeekin and Southerton (2012), who suggest Geels’ (2002) multilevel perspective as an appropriate complement for a theoretical-practical report on consumption.

One of the most relevant justifications for the correlation of both theories is the very suggestion of Alan Warde. It is, however, important to mention a few findings presented by the interesting study carried out by Sovacool and Hess (2017). The authors investigated which theories or concepts are more useful to explain sociotechnical changes. They carried out 35 semi-structured interviews with experts in the field of social sciences, who have also shared more than 200 articles, reports, and books about acceptance, adoption, use, or diffusion of technologies. The investigation led to the identification of 96 theories and conceptual approaches, comprising a total of 22 disciplines identified. Their work shows that, amongst all theories indicated, 14 of them were given greater relevance, amongst which the two best placed approaches were the Theory of Sociotechnical transitions and Social Theory of Practice, respectively.

The studies on sociotechnical transitions emphasize how a necessary change in a sociotechnical system is characterized by gradual evolution in several overlapping areas that constitute this “regime” (Geels & Schot, 2007; Kemp et al., 1998; Weber & Rohracher, 2012). These studies still describe how niche-innovations can replace or reconfigure a dominant sociotechnical “regime” due to the simultaneous destabilization of the regime by the pressures of “landscape” (Geels & Schot, 2007).

TST, just like any other approach, is not free from criticism. Wells and Lin (2015) argue that the definitions of “landscape,” “regime,” and “niche” are ambiguous. For instance, a city with a population of one million represents a “landscape” or a “niche?” Considering the assumptions of TST, this depends on the context. Geels (2002) mentions that the category “landscape” is often used as a common place to categorize everything that is not a “regime” or “niche,” thus, several classifications are added to this category without criteria, like a “trash can.” Shove and Walker (2014) criticize MLP – which is a different name commonly used to refer to TST – for being too focused on structure, neglecting elements like agency and human needs.

As previously mentioned, TP is criticized for overemphasizing agency and underestimating structure, while TST is criticized for overestimating structure rather than agency. Thus, it seems logical to affirm that the integration of both theories provides the study a greater balance in the agency-structure dualism. Moreover, it is possible to affirm that, from a critical perspective, both theories are complementary.

According to Gordon Walker, in an interview with Sovacool and Hess (2017), the Theory of Social Practice decentralizes technology and explicitly recognizes the processes of change, seeing them as deeply integrated into social processes and common conventions. Technology is only a piece of a bigger story. The individual does not start from technology; he/she starts from an activity or practice, and from there he/she assesses how several technologies are integrated in the practices as entities and performances.

Matt Watson, a leading TP scholar and co-author with Elizabeth Shove of several publications, was also interviewed for the study by Sovacool and Hess (2017). Watson argued that sociotechnical transitions are important, but greater emphasis should be placed on how the changes involved in transitions are always limited to changes in social practice. Practices are at the heart of everything. What happens in terms of rhythms, routines, and recursive reactions have significant implications for the system. Studies which go beyond individual practices and immediate action enable the examination of large-scale social phenomena, like sociotechnical systems. Sustainable consumption, energy use, food, or driving, occur only thanks to many other practices. In this scenario, new concepts emerge, such as practice complexes, constellation of practices, and systems practice. Despite a terminology not yet fully established, the Theory of Practice represents a movement towards the understanding of how large social phenomena are apparently made from the same social material, produced, remodeled, and reproduced through social practices.

In this sense, it is important to emphasize the article by Crivits and Paredis (2013), which followed a similar line to that which this study proposes, i.e., the merging of the assumptions and foundations of TP with additional concepts stemming from TST. The authors elaborate an explanatory framework for the role of consumption practices in a transitioning scenario towards a more sustainable food system. To develop an applied practice approach, the authors combined the concept of “practice” with “niche/regime” (derived from the theory of sociotechnical transitions). The recombination proposed by the authors adds a new insight to consumption studies, providing a description that goes beyond the limits of individualist or structuralist models. Amongst the conclusions reached by Crivit and Paredis (2013), one in particular stand out, (i.e., despite the qualitative and systemic differences found in niche and traditional practices) in both cases the perception of consumers about what they need to do is somehow normalized.

Thus, in this study, our aim is to seek additional theoretical support in TST, especially regarding the broader description of the systemic context in which the object is inserted. After all, the object under investigation is highly influenced by issues that come from the “landscape” (economic cycles, for instance) and from the “regime” (regulatory changes, for example). Another positive characteristic from the composition of both theories is the complementarity between them, as MLP “places technology at its heart,” while “Social Practice Theory zooms in on the actions of people” (Sovacool & Hess, 2017, p. 713).

## Method

This research is situated within the interpretivist paradigm. Considering the interpretivist approach, the interest of this study lies in understanding a certain type of behavior, providing a new interpretation for the phenomenon under investigation. This study offers an interpretation of the object from the theoretical lenses provided by the Social Practice Theory and by the Theory of Sociotechnical Transitions, also known as Multilevel Perspective (MLP).

Therefore, the study of practices requires methodological techniques that allow the researcher to explore the individual in depth in a way that, it is possible for the researcher to identify those that are relevant to the study. The researchers must make use of a methodological tool that allows them to move through the tangle of practices that are to be found in the individual. Thus, we have chosen the in-depth interview as the data collection method. Creswell (2014) extols the in-depth interview method by pointing out that these narrative interviews bring an important collaborative characteristic, after all, the story emerges from the interaction, exchange, and dialogue between the interviewer and the participants. The author mentions that, even though interviews are the most utilized way to collect data, narrative stories can be gathered from different ways, such as observation, document analysis, images, among others.

To guide the in-depth interviews, semi-structured scripts were prepared, with a script for each of the three categories of interviewees: integrators, quasi-consumers, and prosumers. To prepare the scripts we sought to merge five large groups of subsidies for preparation: (a) the socio-technical dimensions presented by Geels (2002); (b) factors pointed out by the literature as reasons for migration to the condition of energy prosumer; (c) assumptions brought from my own reflections; (d) questions that emerged from interactions with the integrators; and (e) open questions related to the object. Main groups interviewed in the field research were prosumers and quasi-prosumers, after all, individuals are the carriers of the practice or the point where a whole variety of practices intersect (Halkier & Jensen, 2011; Reckwitz, 2002). Prosumers are the individuals that produce their own energy through microgeneration technologies by means of photovoltaic cells. The quasi-prosumers are those that are still in the

process of change. It should be noted that another group proved to be relevant in the research: integrators, since they have a base of customers and potential customers.

The data collection took place in five phases: two phases refer to in-depth interviews with integrator; two of in-depth interviews with prosumers and quasi-prosumers indicated by the integrators of Phase 1 and 2; and another phase of in-depth interviews with prosumers and quasi-prosumers. In total, 24 interviews were carried out: seven with integrators, seven with quasi-prosumers, and 10 with prosumers. To guide the interviews, semi-structured scripts were elaborated based on the relevant elements identified in the literature review.

The main corpus of the research analysis was the content of the in-depth interviews carried out with prosumers and quasi-prosumers. They totaled about 17 and a half hours of recordings, which generated 234 pages of transcripts. The content of the in-depth interviews carried out with the integrators was handled as complementary corpus; this corpus integrated the data analyzed in this study, but its objective was to support the interpretation of the main corpus. They totaled four hours of recordings and 61 pages of transcripts.

Data were analysed using content analysis (Bardin, 2011). The first categorization we used for data analysis was among those five groups of allowances used for preparing the interview scripts. The identification of themes already contemplated a priori was understood as a first validation of the relevance of these themes for the formatting of the interviews with prosumers and near-consumers. The identification of themes not contemplated a priori was treated as an opportunity to enrich the interviews to be conducted with prosumers and near-consumers. Arriving at a certain variety of themes that presented “repetition,” it was necessary to identify which ones were more important for the research objectives (Ryan & Bernard, 2003).

Given the objectives, we considered two categories of analysis: (1) Influence – prosumers attract new practitioners; and (2) Exhibition – prosumers show off (or not) materialities of the practice. The next section will cover the details on these two categories. To ensure the reliability of the data, we use the constant comparison technique.

## **Presentation and Analysis of Result**

After adopting PV energy, new practitioners begin to take part in a “niche” composed of prosumers. The sociotechnical “regime,” in turn, is formed by regular energy consumers, which represent the vast majority.

Practicing individuals are the carriers of practices (Reckwitz, 2002) and, therefore, the intersection points of a great diversity of practices (Reckwitz, 2002). However, it is possible to observe that practicing individuals also play the role of diffusers of practices, as they interact with non-practitioners.

In this context, we identified in our database a few themes related to how prosumers start to interact with members of the sociotechnical regime. We addressed those which appeared frequently or were relevant to aspects of our work.

### **Influence – Prosumers Attract New Practitioners**

One of the main aspects refer to the influence of practitioners on other individuals in relation to the element “Understandings.” Prosumers report that, in some situations, they are asked to play an explanatory and clarifying role on the aspects involving the presumption of PV energy. Such reports are exemplified in the fragments presented below:

It’s quite impressive, when I was collecting rainwater, I hired this engineer. Oh dear, the bunch of people that came in here. He was doing this work at the Nossa



Fazenda condo, and this bunch of people came to see my photovoltaic system. I opened the door on Saturday about five times. The engineer brought this people to see. And they would ask me and ask me about it, and I answered. I like it, right? I like it. And I answered, and somebody would ask “can I bring a friend of mine?” And this one came; another one brought another one. They even had lunch here at home. They were all amazed. So, I think this is a trend. Thank God people are getting more aware of waste, people are more concerned about their money and about the waste of energy. And the engineer said, “can I bring someone, am I bothering you?” “With the greatest pleasure, I quite like it.” (Prosumer P10)

Prosumers seem to carry a pioneer aura compared to regular consumers. Apparently, it occurs because home energy generation is still a recent technology and not widespread.

It seems that knowing someone, preferably someone close, who has a PV is an important indicator for adoption of PV energy. Having someone – preferably close – as reference seems to confer trust in the reliability of this form of home energy generation:

Even a friend who was a co-worker, he is retired now too, when I told him that I had the system installed, he was very interested, I gave him the material that I had, that the company had sent me. I gave it to him, and I also showed him the energy bill I get by email, and he installed it. He was so interested that he installed it. It’s been two or three months that he’s installed it. [...] And it was only after I told him I had installed it that he got interested. (Prosumer P8)

Prosumers report occasions when they acted as influencers on new practitioners. These same prosumers recalled and reported situations that show how they were also influenced by other practitioners while considering the possibility of becoming prosumers:

From that moment he [interviewee’s son-in-law] informed me about it. And he used to tell me that in the previous house he owned, before moving in here, now that he lives close to me, he had the system installed in the previous house, and it was quite functional, so we decided to install it here too. (Prosumer P9)

Notably, interpersonal influence is widely recognized as one of the main determinants of consumer behavior (Calder & Burnkrant, 1977); in the specific case of PV systems, it seems to be no different: “My brother has an egg production farm in the countryside, in his last shed he has already prepared the roof to support the installation of this system” (Prosumer P9).

However, it is interesting to see how new practitioners can be influenced by individuals who are not necessarily part of their close relationships. In this sense, reports from prosumers about being approached by other aspiring prosumers are common; these aspiring prosumers are usually looking for further information on the practice involved in the prosumption of PV energy. In other words, in some situations the curiosity of non-prosumers seems to be a window of opportunity for them to have contact with prosumers and, therefore, to be somehow influenced: “A postman came here once to deliver a letter, looked at the roof and said, ‘oh, what is that?’ Then I had to explain to him what it was for, and the difference between that and solar heating” (Prosumer P4).

The fact that PV boards are installed in highly visible places, like the roof of houses, seems to instigate this type of interaction between practitioners and non-practitioners. After all, due to its “materiality” nature, the prosumption of PV energy is a practice that ends up being externalized to the sociotechnical “regime.”

The integrators' speeches corroborate the reflection on how the influence of pioneering practitioners in the process of joining new practitioners is important for the prosumption of PV energy:

Seriously, because it is a very new market, people are very insecure, so usually this person, who doesn't know anybody that installed it, is difficult to convince. I'm not saying that it doesn't happen. It happens, but this doesn't represent the majority. Usually it takes one person, right? Someone who indicated, right? You know? That person that knows someone, who knows someone that installed it, even if it's not direct, "oh, I know somebody who installed it", no, but sometimes this person that is talking to you knows someone else who has installed it and then it is mentioned to you, right? Then you decide to look for it and install it. (Integrator I3)

In fact, influence seems to be so relevant to the process of adopting PV prosumption that integrators recognize such aspect as a relevant topic to develop their sales strategies:

Indication is the main channel nowadays, man. I have nothing published, to be honest. I had it at my last company. We had a website, a specific sector, we had a specific person to take care of the digital communication. And today I have nobody. I do the communication work, but most part of the customers that come to us were indicated by people to which we built power plants. (Integrator I5)

### **Exhibition – Prosumers Show Off (or not) Materialities of the Practice**

From a practical-theoretical perspective, the issue of ostentation can be related to the components of the "Meaning" of practices, in other words, the relation to symbolic aspects and image.

The ostentation issue was directly addressed in the initial interactions with integrators; it was also included in the interview scripts applied to prosumers and quasi-prosumers. It is important to highlight that the practice of PV energy consumption in general seems to bring a rationality component, especially for being related to energy efficiency practices and rationalization of energy consumption. Affirmations in which prosumers are quite categorical about their aversion to fads are not uncommon, for instance:

I try to avoid things that are too expensive, when I see that the value for money is not good. If the quality is really good, I can even buy an expensive product, but if it's only because of a certain brand or because it is trendy, I don't usually buy it. (Prosumer P8)

Even so, manifestations of themes that can be associated with the idea of ostentation emerged from the interviews. In fact, one of the interviewed integrators points out that, after lowering the electric bill, the main reason to install PV power systems according to his customers is precisely status:

Well, the "gold medal-winner" [reason] is the wallet, like we said before, right? The "silver medal-winner" is status. Can you believe it? Status. It's basically like a new car, like being at the forefront of technology. (Integrator I6)

When questioned about the ostentation issue, another integrator contributed with two examples of customers who favored the aesthetics of their homes when installing PV power plants.

We had several cases like that, but the most recent is this one in a city called São João Nepomuceno, in the Zona da Mata region. The customer, the house was even new, and the north side of the roof was right in front of the house, you know? So, anyone approaching the house, the house was on a slope, if someone was going down the street, then he would see the solar modules. He said, “I don’t want to install it.” “But dude, this is the north, for power generation.” “No, I prefer to prioritize aesthetics.” I said OK. [...] Then I explained that the generation would be lower, but he said, “no problem.” We had to add more solar modules to make up for it. And it wasn’t the only case, no. There was this other case, a customer from Lavras, he built a house only out of concrete slabs, in a condo. And he didn’t want any modules to be visible. And it was all flat, his house was designed by a famous architect. We had to develop a sort of support for the solar modules to face the slabs. And since he had this asphalt blanket on the slab, we couldn’t drill. We had to somehow string somethings together and it turned out to be kind of cool, it wasn’t visible, nobody could see it. The customer was satisfied. And he also paid more for this. (Integrator I7)

The first example described by Integrator I7 is quite typical, as it illustrates exactly how the introduction of the customer, as the energy producer, brings human elements to be considered, elements that are not related to technical, financial, and regulatory aspects, which most commonly guide the centralized infrastructure for energy generation.

What is unusual is that the example brought by Integrator I7 is like the example presented by Professor Batlle in his lecture, concerning the issue of privileging the visual aspect of the generation power plant instead of its generation efficiency. The reasons for such choice, however, are completely different; while the customers of Integrator I7 wanted to keep their power plants from being seen and, therefore, from affecting the architectural aesthetics of their homes, Californian consumers want to flaunt the sustainable characteristics of their homes.

This same integrator contributed with another example, in which the aesthetic issue involved made it impossible to install the PV system in a potential customer’s home. In the following example, it is possible to observe how the element of “Meaning” transcends the aesthetic aspect, which is related to what one considers beautiful. The element of “Meaning” goes beyond and reaches out to an even more symbolic dimension: “the team of one’s heart”:

There was this case of a house we wanted to install the system in, the owner is related to, she is the sister-in-law of [a former director of a soccer club]. They have a farm here. She is married to the brother of [the former director], his name is [name of the brother of the former director]. And we went there to install it, we designed the project, I showed it to her, and then she said, “wait, these modules are blue? No, nothing in my house is blue.” Then I told her, her name is [name of the customer]. “No [customer], it is blue because of the reflection of the sunlight,” I showed her that the modules are actually black. “Oh no, it’s going to reflect the blue sky, from a distance people will think it’s blue.” And she didn’t let us install it. (Integrator I7)

In this specific case, the quasi-prosumer was guided by her emotional engagements and orientations (Warde, 2005, as cited in Schatzki, 1996). And these emotional aspects were

determining factors for her to abandon the presumption of energy, as the installation of the solar modules implied something she did not want to show off in her house.

Another relevant aspect related to ostentation can be identified by the way through which the practice of energy presumption is considered a factor that enables the ostentation of other practices, or even other “materialities.”

This reflection can be supported by Shove (2017), who claimed that people do not use energy as a resource, but people do make use of the services provided by the resource energy. In this sense, consumption is the result of common practices. In other words, even when the practice of PV energy presumption is not associated with ostentation, it can enable other practices that are related to ostentation.

The following speech, provided by a quasi-consumer, shows an example in which status is attributed to the constant lightning in the house of one of her neighbors; such constant lightning stems from a PV power plant installed in the same house:

A person who lives here where we live deals with photovoltaic energy, he's also a billionaire. He owns a Ferrari. So, he has [PV modules installed] and the lights are on all day long there. Unbelievable. [...] Maybe after the installation we'll be like this neighbor, who leaves everything on in his house. His house is the brightest in the region! (Quasi-prosumer QP6)

The interviewee herself stated that she would like to show off a well-lit house and that, perhaps after installing the PV system, she could leave all lights on, just like her neighbor. She adds that she does not consider PV systems as objects of ostentation, as they are not displayable assets: “[The PV power plant] is something you'll put in your house, and no one will see it. Like, you can't show it off, let's say, as if I had bought a purse” (Quasi-prosumer QP6).

According to the statements and reports, the issue of ostentation is undeniable and, it is related to ideas, symbolism, aspirations, and other cognitive dimensions (Reckwitz, 2002; Røpke, 2009; Shove et al., 2012). It is worth mentioning that, in the data collected herein, the issue of ostentation seems to be more related to the aspects that hamper, and even impair, the adoption of the practice. In other words, it shows how the elements of “Meanings,” or symbolical and aspirational issues, can become limiting factors to the adoption of PV energy presumption.

## **Discussion**

The findings of the research indicate that, based on the assumptions of the theory of sociotechnical transitions and of the multilevel model of innovation introduced by Rip and Kemp (1998), and further developed by Geels (2002, 2004) and Geels and Schot (2007), the presumption of PV energy is a new sociotechnical arrangement developed in a “niche,” in which innovations have been shaped and affected the “regime.”

In this sense, the use of the Theory of Sociotechnical Transitions (TST) was important to complement the practical-theoretical approach, as well as to clarify that the incorporation of the practice by those supporting PV energy indicates a sociotechnical transition, which occurs through the interaction between the “niche,” composed of practitioners, and the “regime,” composed of regular energy consumers. This interaction becomes evident in the reports about how the influence of other practitioners is one of the main reasons to adopt the practice.

Another important contribution of TST to practical-theoretical studies is the possibility of defining, in a more objective way, which sociotechnical approach will be addressed in the study to be carried out. In the case of this research, from a theoretical perspective, everyone

who consumes energy is a potential carrier of practices, or elements of the practices, which somehow can be associated with the presumption of PV energy. However, for obvious reasons, this group is very large and very heterogeneous, which strongly impairs the identification of patterns and similarities during the process of analyzing and describing the database.

During the attempts to interview regular energy consumers, it became clear for us how the lack of an objective clipping that supports the work from a structural perspective can hinder the achievement of the aims of the paper. Both regular consumers and consumers categorized as eligible for consumption represent a very broad and heterogeneous group, within which only a small part knows what PV energy presumption means, and even less understand that its adoption is something feasible.

Based on this observation, it is possible to conclude that the concept of “niche” becomes even more important to delimit the sociotechnical context in which practices are performed. In this sense, the concepts of TST utilized to define “niche” are useful for studying practices that involve some sort of emergent technology, after all, they enable a clearer reflection on the positioning of the phenomenon in a general sociotechnical context. With the support of TST, the presumable-theoretical approach becomes more effective, as the TST avoids its application in a very broad sociotechnical context (i.e., in a very heterogeneous context considering the practices and their elements).

Additionally, we can also conclude that the sociotechnical dimensions presented by Geels’ (2002) MLP can be very useful in studies focused on phenomena that involve the transition of habits, routines, behavior patterns, and practices. Its dimensions can be used as a starting point for approaches with exploratory nature, as they provide a model of assumptions for sociotechnical transition.

We have observed, however to a lesser extent, that the ostentation issue in the presumption of PV energy manifested itself indirectly. In other words, the practitioner does not show off the “materialities” related to the practice of energy presumption, but rather habits and routines that are enabled thanks to the adoption of this practice, constantly associated with luxury and prosperity. We mention, for instance, the use of technological and comfort devices that consume more energy, or even improvements in the house’s external lightning (to the point of drawing the attention of neighbors).

Finally, an interesting aspect, which is not usually present but has emerged with some recurrence, concerns the willingness to no longer depend on external energy supply. It is important to emphasize that the presumption of PV energy, which is the object of this study, does not lead to the complete autonomy of the prosumer; such situation is only achieved after the installation of off grid systems, which are completely disconnected from the electricity grid.

The discussions presented in this section enable us to move on to the final considerations of the article.

## **Conclusion**

In this section, we summarize the aim of this article set out in the introduction, namely, to understand how changes in the consumption of photovoltaic energy affected other spheres of household consumption based on the Theory of Practice and the Theory of Sociotechnical Transitions. The findings of this study show that, from the introduction of a new practice, the sociotechnical systems are reconfigured to accommodate this newly incorporated practice. Additionally, some of the pre-existing practices end up undergoing modifications during this settlement process.

In theoretical terms, this study corroborates literature, as it shows how the articulation between TP and TST is convenient for the development of studies related to consumption in general (Sovacool & Hess, 2017; Warde, 2014). This research supports the conclusions of

Warde (2014), who affirms that TST, especially the multilevel perspective of Geels (2002), presents itself as an adequate partner for the development of consumption studies from a practical-theoretical approach.

More specifically, the combination of TP and TST provides a quite appropriate alternative for examining and investigating how infrastructures and daily life practices are interdependent; how practices related to the use of technological devices change over time; how new emerging technologies interact with consumers and then normalize to develop new social practices, which in turn lead to new lifestyles and behavior standards (Gram-Hanssen, 2010; McMeekin & Southerton, 2012; Shove, 2018; Shove & Trentmann, 2018).

The association between TP and TST presents itself as an opportune theoretical path due to the complementarity of both approaches (Warde, 2014). The practical-theoretical approach emerged recently in consumption studies as a promising approach that shifts the focus from the individual consumer towards the collective aspects of consumption (Gram-Hanssen, 2010). However, even if the purpose of TP is to focus on aspects related to collectivity, it ends up presenting a few ontological characteristics that underestimate structure and emphasize agency, in such a way that it does not always describe the broader systemic dynamics correctly (Sovacool & Hess, 2017). In turn, TST (or MLP) is a promising approach to capture the aspects of a more macro and structural perspective of consumption (Warde, 2014), which is, however, criticized for being too focused on structure, neglecting elements such as agency and human needs (Shove & Walker, 2014). In other words, the combination of the two approaches takes important steps towards a more balanced theoretical lens concerning the agency-structure dualism.

For companies operating in the production and commercialization of residential generation equipment, the findings of this study can be useful to better understand the final consumers. Such understanding contributes to the development of more structured sales strategies, to the presentation of solutions more in line with what the customer wants, to better meet the needs of the consumer, and to improve overall customer satisfaction. The findings of this research clearly indicate that the current argument used to sell PV equipment is too focused on presumption as an investment opportunity; however, we have observed that sustainability also plays a relevant role.

The findings of this study may be also useful for companies operating in the energy sector in general, as it supports the idea of energy presumption, which is still a new phenomenon, but with great transforming potential for the entire electric power industry. Additionally, this article may also contribute to energy infrastructure companies, as it provides a perspective based on social practices, thus quite different from traditional perspectives anchored in technical and economic approaches.

Distribution concessionaires should be the most concerned about understanding the transition of the social practices of their consumers. For these companies, the presumption of energy can have a disruptive impact. After all, a significant part of their revenue source comes from the energy supplied to residential consumers. As the practice of presumption stops being performed only as a sociotechnical “niche” and starts being the current regime, it can drastically impact the business model of electricity distributors.

The findings presented herein can also be useful for policy makers involved in the energy sector. According to Shove and Trentmann (2018), daily practices must be incorporated into infrastructure studies to support a new understanding of how the current forms of resource-intensive consumption emerged, and the consequent growing demand for energy. Such understanding is fundamental for advancing towards a more sustainable future, i.e., a low-carbon future.

Future studies might explore the relationship between energy presumption and the purchasing power of individuals. Some promising alternatives include the investigation of low-

income prosumers and/or quasi-prosumers, how issues related to energy presumption can be affected by the purchasing power of individuals, and which forms of energy presumption can be identified in different social classes. Despite the affirmation by Sovacool and Hess (2017), who claimed that the practical-theoretical approach is less effective to analyze the relationship between practices and space, we suggest further studies to correlate consumption practices and infrastructure.

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