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Appliance-based solar certificates: A new way of going green

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ABSTRACT

In recent years, an increasing amount of solar energy has been produced around the globe, but too few consumers actually buy it. Three studies now show how this purchase can be promoted with an approach similar to the *carbon offset program* in aviation. After a fictitious purchase of differently priced appliances (e.g. electric toothbrush or TV set) in an online store, participants could buy a solar certificate for this appliance, whereby its price depended on the appliance's energy consumption as well as the selected term (e.g. 1 or 3 years) of the certificate. By purchasing such a certificate, the amount of solar energy consumed by this appliance for the selected term would be fed into the Swiss electricity grid. Study 1 showed that participants were willing to buy such a certificate, especially certificates with longer terms. That willingness, however, depended on the "solar certificate price/appliance price" ratio. While Study 2 showed that this purchase is influenced by *promotions* (e.g., a specific reduction in price), Study 3 showed that this purchase did not lead to a less environmentally friendly behavior afterwards. Appliance-based solar certificates easily available at the point of sale can encourage consumers to buy more solar energy.

1. Introduction

The statement "far too few consumers buy solar power" (Witschi, 2017) by Susanne Thoma, the boss of one of the largest energy providers in Switzerland, indicates that too few people are switching to (i.e., buying) *solar power*. Incidentally, this observation applies not only to solar energy, but to *renewable* energies in general in many countries around the globe (see MacDonald and Eyre, 2018). The need to persuade consumers to buy solar power will increase as, in many countries, there is not only a large, so far unused, potential of solar energy (Kabir et al., 2018), through production on house roofs (so-called residential solar electricity) for example, which could be fed into the local power grid, but this energy potential is also expected to double between 2018 and 2024 (International Energy Agency, 2019). This raises the question: Why are consumers not switching to or buying renewable electricity in general and solar energy in particular?

One reason why too few consumers switch to renewable electricity is financial. For example, consumers simply *overestimate* the additional costs of *switching to* renewable electricity. In Tabi et al.'s (2014) study, consumers were expecting additional costs of, on average, 10% (similar results were found by Kühne et al., 2020), although they actually ranged in between 0% and 5% (MacDonald and Eyre, 2018). Thereby, consumers are potentially *willing to pay more* for solar power than for any other type of energy (e.g., Borchers et al., 2007; Cicia et al., 2012). Furthermore, consumers also *overestimate* the *electricity used* by their appliances and therefore the costs that arise therefrom (Attari et al., 2010; Kempton et al., 1985). It is assumed that charging a smartphone 100 times costs 10 euros - that is 17 times the actual average charging price (see the online survey from E. ON, 2018).

However, from a scientific point of view, it is not surprising that consumers cannot accurately estimate prices. This is simply because they do not have an internal value meter that shows them, for example, the *absolute* price (e.g. 35 CHF/month) of a solar power product. Prices are – like many other things – always set in relation to "something else". Hence, consumers might just know that solar power is more expensive than grey energy,[1] and set the price accordingly. The problem, however, is that the price of this so-called reference product is already set *arbitrarily*. This implies that the setting of its price is vulnerable to environmental or irrelevant factors such as an anchor price. For example, depending on the price of the car you might have just bought, you may accept a higher/lower price for grey energy (the price of a bottle of wine has a similar effect on the choice of your menu in a restaurant, see

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[1] Knowledge that sustainable options are more valuable comes from "learning". For example, from learning that organic food is valuable and hence more expensive than non-organic food.

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Ariely, 2008). As a consequence, a large number of different estimated reference prices should be found among consumers (see Kühne et al., 2020 for a confirmation of this). A reference price for grey electricity that is too high will then also drive up the expected price for solar energy. Last but not least, once a price expectation has been set, such as solar electricity is "expensive", it can no longer be changed except at great expense (Ariely, 2008, summarizes this under his concept of arbitrary coherence).

How can we still persuade consumers to buy solar power? Research has now shown that not only price expectations are influenced by irrelevant factors, but also the product itself, or the assessment of its value or quality. This is especially true in the case of so-called low-involvement products. That is, products whose "perceived relevance of the subject matter based on inherent needs, values and interests" (Zaichkowsky 1985, p. 342) is low in the eyes of the consumer. Low-involvement products are, for example, food and beverage items. Hence, Velasco et al. (2013) have shown, that the perceived sensory characteristics of a whisky was influenced by the environment in which it was consumed. In other words, these irrelevant factors can also change the favorability of the product itself and thus alter the decision for or against it. This is most likely possible since one characteristic of these products is that they are quite homogeneous, that is, with not much variation in value (Van der Laan et al., 2012). Energy is also considered a "low-involvement product" (Watson et al., 2002) because its only value variation for the consumer is of an altruistic nature, but the product itself (the electricity that comes out of your socket) is no different between renewable and fossil energy. This is leading to inertia when it comes to changing or buying another (more renewable) energy product.

So what is the potential of these findings? The knowledge that "low involvement products" or their value or quality evaluation are susceptible to irrelevant factors implies that they are processed automatically or intuitively (or by System 1 in Kahneman's thermology, 2011); this in contrast to products with high involvement (e.g. a car). This makes decisions between low-involvement products sensitive to any kind of nudge intervention. A nudge is a simple change in people's decision-making environment to change their behavior in a predictable way (see Thaler and Sunstein, 2009). For example, by putting the *default* on the renewable energy option instead of the grey energy (see Kühne et al., 2020, or Pichert and Katsikopulus, 2008), more consumers choose the renewable energy option. Thereby nudging does not *ban options* (e.g., removing the grey energy from the market) or significantly *increase the options' costs* (e.g., making grey energy very expensive). Although nudges have proven to be extremely effective in a variety of areas, such as the energy industry, the characteristics of successful nudges are still being discussed. According to the EAST framework (Halpern, 2015), one characteristic of successful nudges is that they need to be *simple*. Meaning that no great effort is required on the consumer side to implement the desired behavior.

Nowadays, switching to or buying a solar energy product is not easy. It requires a process consisting of several complex steps (understanding one's own energy bill, comparing possible suppliers, etc.), and is also associated with a few uncertainties (how much it costs more). Due to these difficulties, it seems to be too big a step for many consumers to actively switch to a solar energy product. We need to think about how we can more easily persuade consumers to buy solar power, perhaps in smaller, more affordable units, because Farhar (1999) was able to show that the willingness to pay for renewable energy varies greatly from person to person. By making solar energy not only *easier* to acquire, but also available in different sizes, we can help to ensure that everyone (including those with small budgets) can somehow participate in energy transition.

How this could be done has been shown in aviation. It is difficult, or almost impossible, to get people to give up flying (see the gap in passenger behavior, see Davison et al., 2014), yet airlines (e.g., British Airways in 2005) offer programs to offset CO_2 emissions and thereby passenger can make their flight more sustainable. In such programs customers are asked, by means of a *simple* opt-in procedure when booking a flight, whether they would like to purchase carbon offsets. Though they still fly, they make a small contribution to reducing the carbon footprint. On top of that this contribution is affordable for most customers. The height of offset depends thereby on the specific flight. For example, a one-way flight from Zurich to London would produce on average 186 kg CO_2, which can be compensated by buying a certificate for CHF 5.- (around 5$; Myclimate, 2020).

This led us to wonder whether we could offer consumers something similar to the "carbon offsetting" in the energy sector. Hence, the "solar certificate" is offered to the consumers while buying an electrical appliance in an electronics or online shop. Depending on the selected solar certificate duration (e.g., 1 year), the appliance is supplied with solar power[2] for that period. Besides the fact that such appliance-based solar certificates are affordable to everybody and easy to acquire, they offer some other benefits.

First, they could foster knowledge about the appliance's actual electricity use as well as the additional price of solar energy (e.g., charging my phone with solar electricity for a year costs only 1.- CHF in addition). Second, research (Kogut and Ritov, 2005) on donation behavior has shown that people are willing to spend more money on a few personalized victims than on a large number of unidentified victims. Applied to our context, this could mean that people are willing to pay more for a few specific appliances than for several unspecific energy guzzlers once a month (as if by changing the home's electricity product). Finally, with appliance-based solar certificates, consumers can support small local solar electricity cooperatives (which slightly increases WTP; Sagebiel et al., 2014) and thus achieve a population-based (grassroot movement) energy transition.

Given that we use such certificates, how much would customers be willing to pay for them? Here Brouwer et al. (2008) have shown that travelers' willingness to pay (WTP) for airlines' carbon offsetting programs varies from continent to continent and correlates, among other things, with travelers' awareness of the environmental impact of flying. Furthermore, WTP seems to depend on the income of the traveler (i.e. customers are willing to pay up to 2.36% of their income; see Brouwer et al., 2008) and on the flight distance. Whereby longer flight results in a higher WTP (i.e., up to 0.6 cents per km). Accordingly, the price of a solar certificate should be higher for appliances that consume a lot of energy. However, we assume that energy consumption cannot be the only factor determining price, but also the price of the appropriate appliance. This would be in contrast to the calculation of the price of carbon offsetting, which is determined "solely" by the flight distance. This is because both the carbon offset price and the ticket price depend on the flight distance. However, this is not the case when it comes to the energy consumption of appliances: a cheap appliance (e.g. a kettle) can consume considerably more electricity (72 kWh per year) than an expensive appliance (e.g. a smartphone consumes about 4 kWh per year). The participants' WTP therefore will, assumedly, be an interaction between appliance prices and energy consumption.

To sum up, the aim of the studies described below is to investigate whether appliance-based solar certificates are purchased by consumers based on how factors such as the price of the appliance influence that decision. We, therefore, designed a series of experiments in which, after a fictitious purchase of an appliance, participants were asked whether they would buy a solar certificate for this appliance and of what duration.

Thereby Study 1 examines how the *price and energy consumption of the appliance* (e.g., a toothbrush) influences the purchase of a solar certificate. Study 2 examines how different *product promotions* (e.g. a discount) change the purchase pattern of solar certificates observed in Study 1. In the final Study 3, we examined whether participants who bought a solar certificate subsequently behaved in a less environmentally friendly

[2] For calculation details see method part of Study 1.

manner, that is, do not buy a solar powered product. In the concluding discussion, the results of the studies are summarized and compared with a similar approach, the climate protection programs of the airlines, and political implications are described.

2. Study 1

In our first study we investigated how *the price* and the *energy consumption* of appliances influence the choice of an appliance-based solar certificate and its WTP.

2.1. Method

2.1.1. Participants

424 participants from the ZHAW Zurich University of Applied Sciences and the greater area of Zurich took part in this web-based study. Their age ranged from 18 to 53 ($M = 26.2$; $SD = 6.3$), whereas 69.1% were female. All participants gave informed consent. As an incentive, participants could take part in a draw for cinema coupons respectively students of the School of Applied Psychology could receive course credit instead (which 14.2% overall did).

2.1.2. Stimulus material, procedure and design

At the beginning of Study 1, participants were told – as part of the cover story – that they had just bought an electrical appliance (e.g., a toothbrush) in an online shop and that the shop offers them a solar certificate for this appliance. It was then the task of the participants, in the so-called solar choice certificate task, to decide whether they wanted to buy this solar certificate or not, and if so, with what term (1-year or 3-year; defining the variable term). The four electrical appliances that could be presented to the participants, each represent an instance of the following factor level combination: *price* (low/high) x *energy consumption* (low/moderate). The toothbrush, for example, is a low-priced, low energy consumption appliance. Participants were randomly assigned to one of the four possible combinations or (appliance) conditions (see Fig. 1)[3].

Regarding the solar certificate, participants were informed about how the certificate works, that is how the solar electricity purchased is fed into the Swiss grid, respectively that this is guaranteed by the certificate. Furthermore, participants were informed about which cooperative is behind the solar certificate and that the price of the certificate is calculated as follows: The yearly energy consumption of the appliance (kWh/annum) multiplied with the cost of the solar electricity[4] (CHF/kWh) plus a small profit for the cooperative. Hence, for appliances with a low energy consumption (toothbrush and mobile) the price was CHF 1.- for the 1-year term and CHF 3.- for the 3-year term, respectively for appliances with a medium energy consumption (kettle and vacuum cleaner) CHF 6.- for the 1-year term and CHF 18.- for the 3-year term.

After the participants had completed the solar certificate choice task they had to answer a number of questions, such as: the *willingness to pay* (WTP) for a solar certificate (in % of the appliance price), the personal relevance of a solar certificate (7-point Likert scale), the simplicity of the purchasing process (also 7-point Likert scale), whether the solar certificate was comprehensible (yes or no). In order to check whether the last question - out of laziness - was not just answered with yes or no, comprehensibility was assessed with additional questions (e.g., "by purchasing the solar certificate, additional solar power is directly fed into the socket of my home"). At the end of the study participants had to answer some socio-demographic questions (e.g., income, age, sex).

2.2. Results

From the 461 participants who completed the experiment, 37 participants had to be excluded from the further analysis. Twenty-two of them because they needed less than 150 or more than 1800 s for completing the study; another 14 participants because they needed less than 10 s or more than 300 s for the solar certificate choice task. Furthermore, one participant inserted "199" as age and was therefore excluded.

2.2.1. Solar certificate choice task

2.2.1.1. Overall model. Statistical analyses were performed using R Statistical Software. First, we calculated a multinomial logistic regression with Price and Energy consumption as the independent variables for the term chosen. We thereby found a significant main effect of Energy consumption, χ^2 (2) = 28.23, $p < .001$, as well as a significant interaction effect of Price x Energy consumption, χ^2 (2) = 8.44, $p < .05$, but no significant main effect of Price χ^2 (2) = 4.26, $p = .12$ (see Fig. 2).

2.2.1.2. Detailed analysis. Descriptive statistics showed that 20.3% of the participants, did choose not to buy a solar certificate, while 20.5% did choose to buy a certificate with a 1-year term respectively 59.2% a 3-year term.

Thereby, pairwise comparisons (with the Least-Square Means method; Tukey adjusted[5]) showed, that *the estimated probabilities* of participants that chose to buy no certificate ("0 Term [in Years]" in Fig. 2 or our so-called reference point) did not significantly differ from those for the 1-year term.[6] However, compared to the reference point a significant increase in the number of participants that chose to buy a certificate with a 3-year term for all appliances was found (electric toothbrush; t (8) = 7.80, $p < .001$, smart phone; t (8) = 8.23, $p < .001$, vacuum cleaner; t (8) = 5.35, $p < .01$; with the exception of the electric kettle, t (8) = 0.22, $p = 1.00$).[7]

With regard to the 3-year term, we wondered which factor combination (i.e., which appliance) was the most chosen one? Pairwise comparisons showed, that the probability of choosing a 3-year term was higher for the toothbrush (t (8) = 5.59, $p < .01$) and the mobile (t (8) = 4.68, $p < .05$) than for the kettle. However, the vacuum cleaner did not differ from the kettle condition; t (8) = 3.51, $p = .09$.

2.2.2. Questions

Willingness to pay. Most participants (73%) did not only show a willingness to pay for an appliance-based solar certificate, but also up to 13% ($SD = 10$, $Min = 1$, $Max = 90$) of the appliance price.

Acceptance and understanding of the certificate. The participants considered the solar certificate as personally relevant (M = 4.62, SD = 2.00) as well as simple to purchase (M = 5.34, SD = 1.72). Furthermore, 70% of the participants thought that they had understood the solar certificate; this was supported by our data, showing that in the mean per control question 75% of the participants answered them correctly.

2.3. Discussion

Overall, Study 1 showed that about 80% of the participants bought a solar certificate, 20% of them a 1-year certificate and about 60% even a

[3] Note, the pictures from the original studies differed slightly from the ones depicted here. The original pictures cannot be depicted do to copyright reasons.

[4] 0.07 CHF/kWh at the time of the study.

[5] If not stated otherwise we used Tukey adjusted tests for all pair-wise comparisons in all studies. In the first study the correction was for 30 planed contrasts.

[6] All pair-wise comparisons between term 0 and 1 were not significant (all p's > 0.68).

[7] All pair-wise comparisons between term 1 and 3 were significant (all p's < 0.05), with exception of the kettle; t(8) = 1.19, $p = .92$.

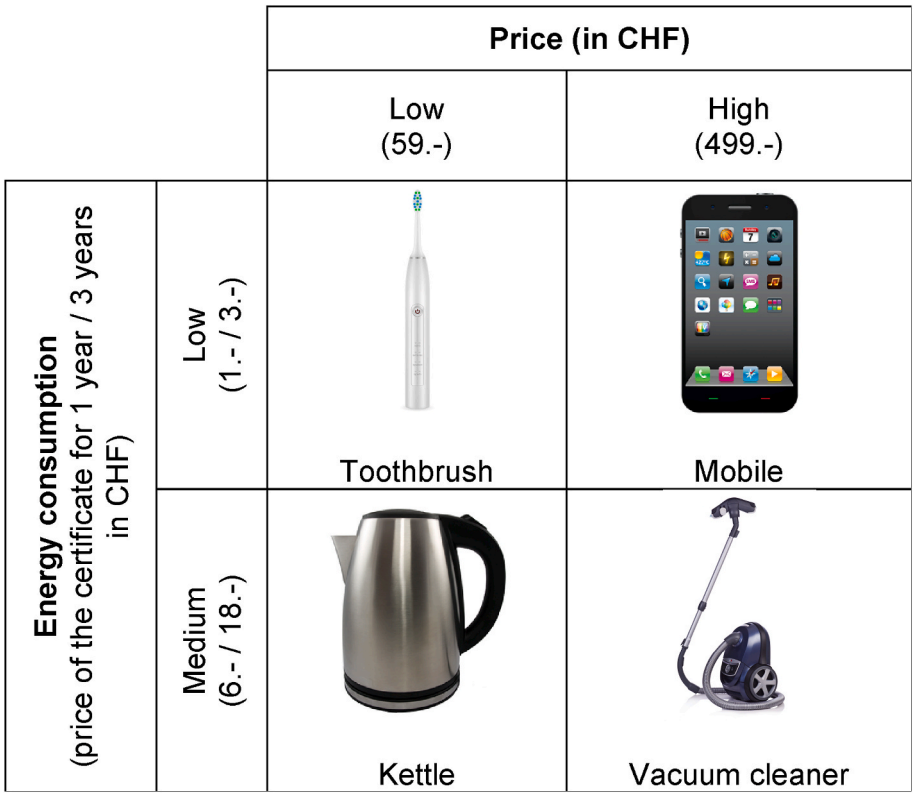

Fig. 1. The appliances in the different conditions in study 1.
Note. The presented appliances had two characteristics: energy consumption (low/medium) and price (low/high).

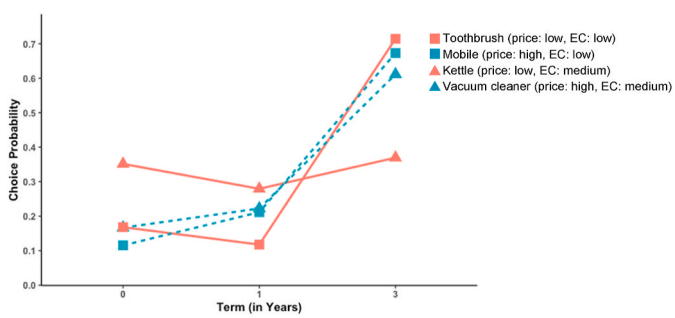

Fig. 2. Choice probabilities in study 1.
Note. The estimated probabilities to choose a certificate for each of the three certificate terms depending on the factors price and energy consumption are shown.

3-year certificate; only in the case of the kettle was the certificate with the 3-year term chosen less frequently. Compared to the number of passengers who buy a climate protection program, our numbers are definitely higher (e.g., 10% in the case of Quantas Airways,[8] see Freed, 2016). The critical point for/against buying a solar certificate with a 3-year term seems to be the level of the "solar certificate price/appliance price" *ratio*. From the answers out of the "willingness to pay" question, we assume that this level lies somewhere around 13%. The kettle exceeded this level (CHF 18.-/CHF 59.- = 31%) and hence was bought less often. Overall the solar certificate seems to be of personal relevance, simple enough to buy, and easily understood.

3. Study 2

In Study 2, we wanted to further investigate whether buying a solar certificate is actually determined by the "solar certificate price/appliance price" ratio. Furthermore, we wanted to investigate the effects of product *promotions*, not with regard to the purchase of the *promoted* product itself, but with regard to the later purchase of a solar certificate. As there is, to our knowledge, no such research, we drew our conclusions regarding the expected effect based on research on the effects of purchasing the promoted product itself. It is known that *price reductions* – as the most typical example of a promotion – lead to an increase in sales for each type of product (e.g., a TV; see for an overview Gedenk et al., 2006). However, do promotions also have a beneficial effect if the promoted product is not, for example, a TV but a donation to a charity organization and is thus associated with social value creation[9] or pro-social behavior, when viewed at the individual rather than the company level? Not according to Newman and Shen (2012). Their participants donated less money to a charity organization when they got a promotion in the form of a (free) thank you gift. Back to our situation where, unlike in the study by Newman and Shen (2012), the promotion is not on the target product (here: solar certificate), but on the appliance (i.e. the kettle). Are their results nevertheless transferable, in the sense that product promotions will have a negative effect on the purchase of solar certificates, since the later behavior can also be regarded as prosocial?

To compare the results of Study 2 with those of the first study, we again use the kettle as a reference appliance, but add two new "appliances": LED-Lightbulbs and a TV.

[8] Please note that our participants did not really have to make the payment compared to the Quantas example. This could explain the difference.

[9] We use the term social value creation here for any behavior that creates value for the environment (in nature and society) as for example, donate to a charity or reduce one's own greenhouse gas emissions.

3.1. Method

3.1.1. Participants

718 participants from the ZHAW Zurich University of Applied Sciences and the greater area of Zurich took part in this web-based experiment. Their age ranged from 18 to 51 ($M = 24.3$; $SD = 4.8$), whereas 62.5% were female. All participants gave informed consent. As an incentive, participants could take part in a draw for two iPads respectively students of the School of Applied Psychology could receive course credit instead (which 1.8% overall did).

3.1.2. Stimulus material, procedure and design

The set-up of Study 2 was identical to the first study with the following two exceptions: First, in addition to the kettle (inexpensive, but with medium energy consumption), participants were presented with either a set of ten LED Lightbulbs (inexpensive, but with a high energy consumption), or a TV (expensive and with high energy consumption). Second, the appliance could be presented with no promotion ("regular" condition) or with one of the two following promotions: Either with a discount price of CHF 5.- or 10.-, depending on whether the price for the 1-year solar certificate for that appliance was CHF 5.- or 10.- (discount condition) or with a "free" 1-year solar certificate included (of either CHF 5 or 10; solar certificate [included] condition).

Participants were again randomly assigned to one of the 9 conditions that resulted from the combination of the following 2 factors: *Appliances* (Kettle, LED, TV) and *Promotion* (regular, discount, solar certificate; see Fig. 3).

As before, after the participants had completed the solar certificate choice task, they had to answer a number of questions. Whereby some questions, such as whether they would also be willing to buy a solar certificate for other appliances (yes or no) and if so, for how many (number) or why (simple selection from 7 possible reasons given[10]), were only given to those participants who had decided to buy a solar certificate. The same was true for the question of how much money (in CHF) they would spend in total on solar certificates. Further questions such the optimal duration of a solar certificate (individual selection from 8 possibilities[11]) and the socio-demographic questions (e.g., income, age, gender) were given to all participants.

3.2. Results

From the 751 participants who completed the study, 33 participants were excluded from further analysis. Fourteen of them because they needed less than 120 or more than 1800 s for completing the study; another eighteen participants because they needed less than 10 s or more than 300 s for the critical solar certificate choice task. One participant was excluded because of presumably entering the year of birth instead of the age.

3.2.1. Solar certificate choice task

3.2.1.1. Overall model. As in Study 1, we calculated a multinomial logistic regression with Appliance and Promotion as predictors for the term chosen. We thereby found a significant main effect for Appliance, χ^2 (4) = 12.50, $p < .05$ as well as Promotion χ^2 (4) = 10.34, $p < .05$, but no significant Appliance × Promotion interaction effect, χ^2 (8) = 7.23, $p = .51$. Since there was no significant difference between the regular condition and the discount condition, χ^2 (2) = 0.38, $p = .83$, they were hereafter consider as one, the R&D condition.

3.2.1.2. Detailed analysis. Descriptive analysis showed that participants' choosing probabilities were equally divided between buying no solar certificate (30.9%), the 1-year term (33.7%) and the 3-year term solar certificate (35.4%).

Thereby, pairwise comparisons[12] showed that in each condition the estimated probabilities of participants who did not buy a certificate (again our reference point) did not significantly differ from those who bought a 1-year term certificate (all p's > 0.80; see Fig. 4). However, compared to the reference point, only participants in the TV and R&D condition, t (8) = 4.62, $p < .05$, but not in any other condition (all p's > 0.22)[13] did buy, significantly more often, a certificate with a 3-year term. As in Study 1, when the ratio "solar certificate price/appliance price" became too high, participants seemed no longer to be willing to buy the certificate.

With regard to the 3-year term, we found – within the R&D condition – no differences between the three appliances (the LED – TV comparison is marginally significant; t (8) = 4.29, $p = .053$; the other comparisons: p's > 0.39); the same pattern was found for the solar certificate condition (the LED – TV comparison is marginally significant; t (8) = 4.16, $p = .062$; the other comparisons: p's > 0.41). Interestingly, however, the probability of participants buying a solar certificate was significantly lower in the solar certificate condition than in the R&D certificate condition for every appliance (Kettle t (8) = 4.59, $p < .05$, LED t (8) = 4.55, $p < .05$, and TV t (8) = 4.58, $p < .05$).[14]

3.2.2. Questions

Solar certificates for other appliances. Of the participants that did choose to buy a certificate, 91% indicated that they would buy certificates for other appliances (on average for another 4.68 appliances, $SD = 6.49$, Min = 1, Max = 100). The reason for this was mostly (84%) the promotion of environmentally friendly electricity. Furthermore, participants were willing to annually pay on average CHF 110.56 ($SD = 142.50$, $Min = 5$, $Max = 1000$) for solar certificates.

Preferred duration of the certificate. 43% of all participants would prefer a certificate for the average lifetime of appliances, 20% for a 1-year term, 10% a 2-year term, 10% a 3-year term, 8% a 4, 5- or 10-years term. 7% of the participants stated that none of the listed durations is suitable for them.

3.3. Discussion

Study 2 not only replicates the results of the first study that with an increasing "solar certificate price/appliance price" ratio the 3-year term certificate is chosen less frequently (see kettle and LED) but also shows a broad support for the solar certificate (seen in the number of solar certificates they would buy for additional appliances, etc.). Furthermore, promotions seem to have a differential effect on choice. The regular price and the discount promotion thereby seemed to have an advantage (in "term 3") over the solar certificate promotions. The question is, why did those solar certificate promotions backfire?

[10] The 7 Reasons were: "the price of the solar certificate is appropriate", "the duration I prefer is provided", "the purchase is easy", "I have a bad conscience", "I would like to support environmental-friendly electricity", "I don't know" or "other reason".

[11] The 8 possibilities were: "1 year", "2 years", "3 years", "4 years", "5 years", "10 years", "average lifetime of the appliance" and "none of the listed lifetimes conforms my wishes".

[12] As in the first study we used Tukey adjusted tests for all planed (overall 63) pair-wise comparisons.

[13] All pair-wise comparisons between term 1 and 3 within the promotion conditions were not significant (all p's > 0.38), with exception of the TV in the R&D condition, t(8) = 4.85, $p < .05$ and the LED in the certificate condition, t (8) = 5.06, $p < .05$.

[14] The probabilities to choose a 1 year did not differ within the appliances for the promotions (all p's > 0.21).

		Appliance *Price (in CHF)* Energy Consumption (Price in CHF for 1 year / 3 years)		
		Kettle  *Low (59.-)* Medium (5.- / 15.-)	**10 LED Lightbulbs**  *Low (59.-)* High (10.- / 30. -)	**TV**  *High (590.-)* High (10.- / 30.-)
Promotion	**Regular**	CHF 59.-	CHF 59.-	CHF 590.-
	Discount	SALE CHF 54.- instead of 59.-	SALE CHF 49.- instead of 59.-	SALE CHF 580.- instead of 590.-
	Solar Certificate (included)	SALE CHF 59.- with 1-year solar certificate included	SALE CHF 59.- with 1-year solar certificate included	SALE CHF 590.- with 1-year solar certificate included

Fig. 3. The different conditions in study 2.

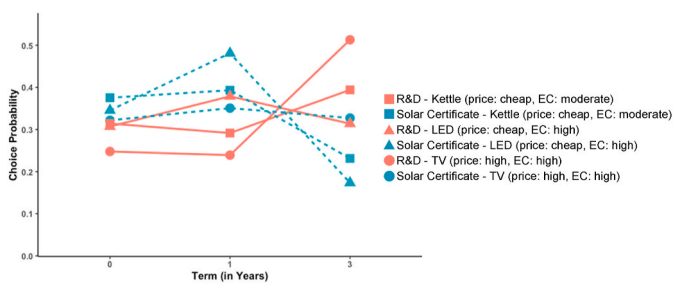

Fig. 4. Choice probabilities in study 2.
Note. The estimated probabilities to choose a certificate for each of the three certificate options depending on the factors Promotion (Certificate and R&D = Regular & Discount combined) and Appliance (Kettle, LED, TV) are shown.

4. Study 3

In the study by Khan and Dhar (2006) participants had to choose *between two equally expensive items*, this after a group of participants (as opposed to a control group) was instructed to imagine that they had just displayed an altruistic behavior (such as weekly volunteer work in a community service). One item (e.g., designer jeans) was of hedonistic nature, that is, there to satisfy sensual pleasure. The other item (e.g., vacuum cleaner) was of utilitarian nature, that is, there to satisfy a basic need. The authors found that if the participants had previously displayed altruistic behavior, they were much more likely to choose the designer jeans, the luxury article, than the participants in the control group. The phenomenon that after an altruistic behavior (here; through imagination), a hedonistic behavior is shown is summarized under the term "moral self-licensing effect" (for an overview see Merritt et al., 2010).[15] This phenomenon may well explain the behavior observed in our Study 2: If a promotion included a "free" solar certificate (social value creation) for a 1-year term, participants were less willing to buy another certificate with a 3-year term. The question is, can we find this effect also in a broader context? More specifically, do people who just bought a solar certificate behave subsequently less environmentally-friendly, such as by not buying a solar electricity product?

4.1. Method

4.1.1. Participants

675 participants from the ZHAW Zurich University of Applied Sciences and the greater area of Zurich took part in this web-based experiment. Their age ranged from 18 to 52 (M = 25.1; SD = 4.8), whereas 62.5% were female. All participants gave informed consent. As an incentive, participants could take part in a draw for one iPad and 2 cinema coupons respectively students of the School of Applied Psychology could receive course credit instead (which 4.6% overall did).

4.1.2. Stimulus material, procedure and design

The set-up of Study 3 was identical to the first study with the following three exceptions: First, participants were only presented with one appliance: a TV. We, however manipulated the price of the TV, which could be either moderate (399.- CHF) or high (799.- CHF). Using the TV as stimulus material enabled us to set the price of the solar certificate at a level that is within the range of an annual subscription to solar energy (for the reason see exception number 3). Second, we did split up the former triple-level dependent variable (no certificate, a 1-year term and a 3-year term solar certificate) into 3 double-level or binary dependent variables (yes/no; see Fig. 5 for the possible combinations). For example, participants in the "1 Year" condition could choose between a certificate for 1-year or no certificate. Instead of the 3-year term we used in two levels a lifetime certificate choice, one cheap (47.- CHF, for a highly energy efficiency TV) and one expensive (95.- CHF, for an energy inefficient TV). On top of that, we added a control group that did not get the solar choice certificate task. Third, we added a second task (solar energy product choice task) wherein the participants received the cover story that one month after their purchase in the online shop they will be offered an annual subscription (for 105.- CHF) for solar energy. They could accept this offer or not (yes/no answer).

Participants were again randomly assigned to one of the 8 conditions that resulted from the combination of the following 2 factors: Price (moderate, high) x Solar Certificate Option (1 year, lifetime cheap,

[15] There are two theoretical models explaining the moral self-licensing effect. Either it is seen as a kind of moral credit system, whereby virtuous behaviors deposit and hedonic withdraw from the moral bank account (see Nisan and Horenczyk, 1990). On the other hand the moral credential model which argues that "past behavior serves as a lens through which one construes current behavior" (Merritt et al., 2010, p. 349).

		Price of the TV 	
		Moderate (399.- CHF)	**High (799.- CHF)**
Solar certificate option	**1 Year**	Binary choice: ○ 1 year for 10.50 CHF ○ No certificate	Binary choice: ○ 1 year for 10.50 CHF ○ No certificate
	Lifetime: cheap	Binary choice: ○ Lifetime of the TV for 47.- CHF ○ No certificate	Binary choice: ○ Lifetime of the TV for 47.- CHF ○ No certificate
	Lifetime: expensive	Binary choice: ○ Lifetime of the TV for 95.- CHF ○ No certificate	Binary choice: ○ Lifetime of the TV for 95.- CHF ○ No certificate
	Control group	No certificate was offered to the participants.	No certificate was offered to the participants.

Fig. 5. The different conditions in study 3.
Note. In the control group participants did not take part in the solar certificate choice task.

lifetime expensive, control group; for details see Fig. 5).

After the participants had completed the second task (respectively the first one for the control group), the solar energy product choice task, they again had to answer a number of questions such as whether they would buy a solar certificate for an appliance at all (yes/no), and if so, how much they would be willing to pay for an appliance-based solar certificate for a 1-year term and for a lifetime term of the appliance (in % of the price of the appliance). Furthermore, they were asked what kind of energy product they have at home (mixed [partly from fossil or nuclear sources], green or solar energy or "don't know"). Last, but not least, we did ask some demographic questions and did check with a control question (hidden in a matrix-question whereby participants were instructed to click on a specific value) if participants did pay attention to the tasks at hand.

4.2. Results

From the 719 participants who regularly completed the experiment, 44 participants were excluded from further analysis. 13 because they did not answer the control question correctly, 2 because they participated twice in the experiment and 21 participants because they needed less than 120 or more than 1800 s for completing the experiment respectively 8 because they needed less than 5 s or more than 300 s for one of the two critical decisions (solar certificate choice task or solar energy choice task).

4.2.1. Solar certificate choice task

4.2.1.1. Overall model. We calculated a logistic regression with Price and Certificate as independent variables for the term chosen (i.e., a certificate with a term of a certain length/no certificate). We thereby found a significant main effect for Certificate, χ^2 (2) = 8.33, $p < .05$, but not a significant main effect for Price χ^2 (1) = 0.61, $p = .44$, nor a significant Price × Certificate interaction χ^2 (2) = 2.61, $p = .27$. Therefore price was not considered as a separate factor anymore in the further analysis.

4.2.1.2. Detailed analysis. Descriptive analysis shows that overall 73.2% of the participants did choose to buy a solar certificate. Furthermore, comparisons (using Wald tests; see Fig. 6) showed that the cheap lifetime certificate (independent of the TVs price) was chosen more often than the expensive lifetime certificate ($\beta = 0.75$; χ^2 (2) = 8.94, $p < .01$); the comparison with the 1 year certificate, however, was only marginally significant ($\beta = 0.47$; χ^2 (2) = 3.28, $p = .07$). Between the expensive lifetime certificate and the 1 year certificate there was no significant difference ($\beta = 0.28$; χ^2 (2) = 1.37, $p = .24$).

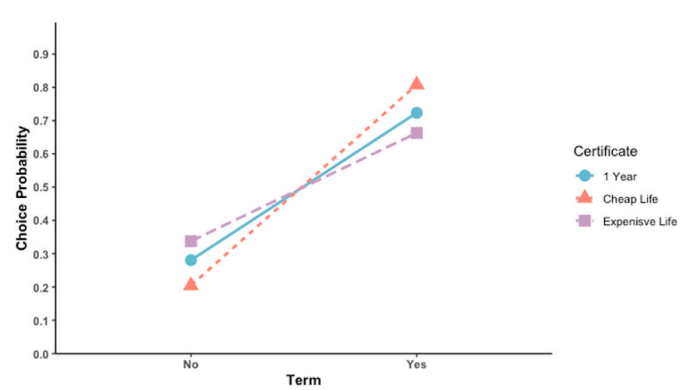

Fig. 6. Choice probabilities in study 3 for the certificate task.

4.2.2. Questions

Willingness to pay. 68.3% of the participants stated that they would buy an appliance-based certificate; for a 1 year certificate they would pay up to 17.9% ($SD = 16.3$), for the lifelong certificate up to 35.3% ($SD = 21.7$) of the appliance price. Note, participants are willing to pay significantly more for a lifetime certificate; $t\ (343) = 20.84$, $p < .001$.

4.2.3. Solar energy product choice task

4.2.3.1. ***Overall model.*** Here we also calculated a logistic regression with Price and Certificate as independent variables on (solar energy) product choice (yes/no). We thereby found neither significant main effects (Certificate, $\chi^2\ (3) = 2.41$, $p = .49$; Price $\chi^2\ (1) = 0.77$, $p = .38$), nor a significant Price × Certificate interaction effect, $\chi^2\ (3) = 2.94$, $p = .40$.

Moral Self-Licensing Effect. The important question, however, is whether the choice pattern in this second choice task differs depending on what the participants have chosen in the first, the solar certificate choice task. This shows us whether an altruistic behavior will result in a less environmentally friendly behavior, such as not buying the solar energy product. We again calculated a logistic regression with Certificate and Choice1 (i.e., the choice in the solar certificate choice task) as independent variables on product choice (yes/no).[16] We thereby found a significant main effect of Choice1, $\chi^2\ (1) = 34.53$, $p < .001$; the other main as well as the interaction were not significant; Certificate; $\chi^2\ (2) = 4.47$, $p = .11$; Choice1 x Certificate $\chi^2\ (2) = 4.88$, $p = .09$.

4.2.3.2. Detailed analysis. The descriptive analysis showed that a total of 65.3% of the participants chose the solar energy product (i.e., 64.8% of the participants in the groups that received the solar certificate task, 67.1% in the control group – dotted line in Fig. 7). Regarding the groups that received the task with the solar certificate, it was found that in the cases where the participants had bought a certificate, 75.0% of them also bought the solar energy product. However, if the participants had not bought the certificate, only 36.8% of them bought the solar energy product.

Post-hoc comparisons using Pearson chi-square tests with Bonferroni correction were calculated to more thoroughly understand the pattern of the solar energy product choices. Thereby, we saw that there was no significant difference between the control group and any average of any of the other groups regarding the number of solar energy products bought: $\chi^2\ (1) = 0.09$, $p = .77$. Similarly, participants in the control did not significantly buy more or less products when compared to any of the three groups that did buy a solar certificate in the first choice task (all $\chi^2 < 4.00$, all $p > .45$). However, when the participants in the control were compared to each one of the three groups that did not buy a solar certificate in the first choice task, we see a significant difference in each comparison: 1 year: $\chi^2\ (1) = 24.72$, $p < .001$, life cheap: $\chi^2\ (1) = 7.92$, $p < .05$, or life expensive: $\chi^2\ (1) = 7.98$, $p < .05$ (for an overview, see Fig. 7).

Comparison of the 3 vs. 2 option choice set. Which choice set size, that with three (e.g., Study 1 or 2) or two (Study 3) options is more beneficial regarding selling solar certificates? To answer that question, we compared the number of choices in Study 2 (i.e., the "regular" TV) where participants could chose the 1 or 3 years certificate (which 79.5% did) with the number of choices for the 1 year certificate in Study 3 (where 72.2% of the participants did choose it). The proportion test, however, showed no significant difference, $\chi^2\ (1) = 1.18$, $p = .28$.

Electricity product at home. 42.5% of the participants seem to have an energy product that contains nuclear or fossil power. 16.6% of the participants have an energy product that contains 100% renewable energy respectively 6.1% have a product containing 100% solar energy.

[16] The control group is of course not included in this analysis.

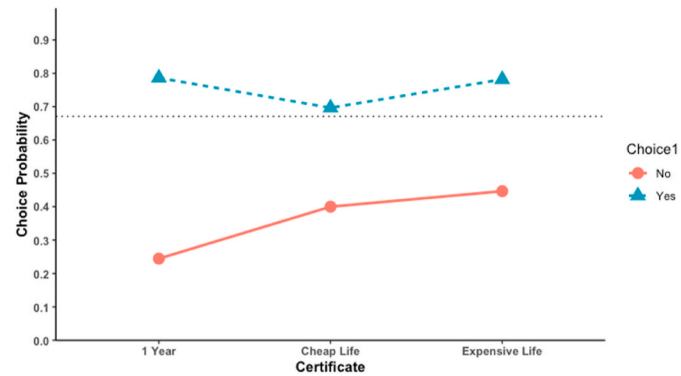

Fig. 7. Choice probabilities in study 3 for the solar product choice task.
Note. The estimated probabilities to choose a solar product (second choice) predicted by the factors first choice (appliance-based certificate) are shown. The dotted horizontal line indicates the reference group which did not see a first choice.

34.8% of the participants did not know what kind of an energy product they have at home.

4.3. Discussion

The results of Study 3 indicate that even with a binary choice set, quite a high number participants do buy an appliance-based solar certificate. Thereby the price of the TV had no effect on the choice of the solar certificate (first choice) nor on the solar product (second choice). Moreover, results indicate that participants did buy shorter 1-year certificates as often as lifelong certificates: whereby regarding the later, more were sold when the appliance was energy efficient (expensive life) than when not (cheap life). Therefore, in the case of the lifetime certificates, participants accepted certificates that cost significantly – namely 9 times – more than the 1-year certificates. This result is backed-up with the results from the explicit question about participants willingness to pay for lifelong certificates in general, where participants stated that they are willing to pay on average up to 35% of the price of the appliance. Furthermore, the behavior of the participants that did buy a solar certificate (hedonic first choice) did differ from the behavior of the participants that did not buy a solar certificate (virtuosic first choice) regarding the percentage of buying a solar energy product (second choice). This is contradictory to the moral self-licensing effect, but in line with theories that assume that people tend to act consistent over time (see for an overview; Gawronski and Strack, 2012).

Though it is still debated under which circumstances people will show consistent or inconsistent behavior. The few moderator variables discussed so far in studies (see Mullen and Monin, 2016; Merritt et al., 2010) cannot explain (or even contradict; see "Construal Level Theory" in Mullen and Monin, 2016) why in our study the participants showed consistent behavior, but not in the mentioned studies (e.g., Khan and Dhar, 2006; Tiefenbeck et al., 2013).

Last but not least, our results indicate that a high number of participants were not aware of the energy product they have. This is a result that can also been found in other studies (e.g., Kühne et al., 2020) and is indicative of the low involvement of people in the energy product.

5. Conclusion and policy implications

In three studies, we investigated whether appliance-based solar certificates can persuade consumers to buy more *solar energy*, respectively what exactly these certificates should look like.

Overall, those certificates were often chosen (i.e., chosen to be bought) by the participants. The first study thereby showed that the "solar certificate price/appliance price" *ratio* mattered. The energy consumption of the appliance seemed not to be relevant. The second

study showed that a monetary discount on the appliance itself did not change the before (Study 1) observed pattern; whereas a promotion that includes a free certificate does: fewer participants chose to buy the certificate. The third study showed the robustness of the observed pattern: changing the size of the choice set did not change anything. Furthermore, there seem to be no negative long-term consequences from buying a certificate: participants that did chose to buy a solar energy certificate did not less often buy a solar electricity product as the one that did not have the option to buy a solar energy certificate.

Our results thus show that buying a certificate was easy. This was one of the basic requirements to create successful nudges (see Halpern, 2015). Another "requirement" that could probably have worked in our favor, and which is part of the EAST framework (Halpern, 2015), is the social factor. Man is a deeply social being and is therefore constantly influenced by other people. In that vein, Gerpott and Mahmudova (2010) have shown that when we believe that our own *social environment*, such as our friends and family, would support the switch to green energy, more of us make that switch. Hence, the social environment makes us act in a more environmentally-friendly way by making us put our "good intentions" into practice. However, our social environment can make us change our behavior by creating a sense of *guilt*, for example, by not acting green enough (see Nyborg et al., 2006). This was induced by a Swedish social norm called "flygskam" or "flight shame" (which, by the way, resulted from increased environmental awareness) with the goal to encourage people to fly less. Its success is reflected in a 4 percent decline in passenger flights in 2019 (Swedavia, 2020), and also a reported increase in the number of *carbon offsets* bought (Gross et al., 2019). Similarly, our certificates could probably also reduce such a feeling of guilt by adding an option to behave altruistically in the moment of consumption.

Of course, overall it would be better for the environment if people would not fly, consume less (e.g., energy), and switch entirely to renewable energies, but we think it is important to offer alternative, albeit smaller, steps (like the carbon-offset programs) towards environmentally friendly behavior in order to involve as many people as possible in the energy transition.

The solar certificate also provides policy makers with an instrument with which they can change people's decision-making in ways other than the traditional ones, for example by banning or introducing taxes on grey energy. Another example is that policy makers can *encourage* retailers to offer these certificates as optional extras on their appliances. This would be similar to the food sector where the Swiss government is currently encouraging retailers to voluntarily place the Nutri-Score food label on their food products to combat obesity. Since, in the case of appliance-based solar certificates, retailers receive a small portion of the retail price of the certificate for their services, it should be possible to find retailers who offer them voluntarily. However, the sale of solar certificates is only seen as another instrument to promote the purchase of solar electricity and should therefore be accompanied by other interventions.

Nonetheless, solar certificates could involve people in the energy transition and thus help in the fight against climate change. Next step would be to implement the solar certificate in a real world setting by, for example, placing them at a check-out of an online shop selling different appliances.

Author Contributions

SK and ER made an equal, substantial, direct and intellectual contribution in all phases of the work. RR was involved in the design, conduction and data analysis of the experiments. All authors approved the manuscript for publication.

CRediT authorship contribution statement

Swen J. Kühne: substantial, direct and intellectual contribution in all phases of the work. **Ester Reijnen:** substantial, direct and intellectual contribution in all phases of the work. **Reto Ritter:** was involved in the design, conduction and data analysis of the experiments. All authors approved the manuscript for publication.

Declaration of competing interest

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

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