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Acceptance among residential electricity consumers regarding scenarios of a transformed energy system in Switzerland—a focus group study

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Abstract The Swiss energy system will undergo successive restructuring in the next decades as a result of recent decisions in energy policy (Switzerland's Energy Strategy 2050) and the expected second step in the market liberalization process (free choice of provider for small customers). This transformation will probably lead to the following trends: an increasing share of renewable energies, a shift from centralized to distributed generation and the emergence of new players in the energy market. Because of the associated integration of renewables, the grid will increasingly face problems of intermittent loads, the need to integrate smart information and communication technology, and mechanisms for demand-side management. However, these key elements of the future energy system also raise issues concerning social acceptance, as they tend to interfere with basic human needs like autonomy and privacy. Additionally, market liberalization may reshuffle existing customer utility relationships considerably. This focus group study contributes to understanding residential consumers' attitudes and expectations regarding four scenarios of future utility/customer interactions in the Swiss electricity sector (dynamic tariffs, direct load control, energy storage and novel energy services). The findings show that as to acceptance of future scenarios, there are no "one-fit-for-all" solutions, as the needs of different consumer groups are very diverse. However, the analyses reveal that for acceptance of novel models of interaction, transparent communication and a trusted relationship are crucial. The discussion touches on practical implications for research, policymaking and electric utilities' market strategies.

Keywords Smart grid · Distributed energy storage · Residential consumer · Demand-side management · Behaviour · Market liberalization

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Introduction

The Swiss energy system will undergo successive restructuring in the next decades, as a result of Switzerland's decision to decommission its nuclear plants at the end of their safe service life (Swiss Federal Office of Energy 2016), its commitment to reduce its greenhouse gas emissions by 50% by 2030 (compared with 1990) (Federal Office for the Environment FOEN 2015) and the expected second step of the market liberalization process (free choice of provider for small customers). An increasing share of renewable energies (e.g. solar and wind), a shift from centralized to distributed power generation and the emergence of new players in the energy market are expected to be prominent trends within this transformation (Wolsink 2012; Parag and Sovacool 2016). Because of the associated integration of renewables, the grid will increasingly face problems of intermittent loads, the need to integrate smart information and communication technology, and mechanisms for demand-side management (DSM).

The above-described key elements of the future energy system may raise issues concerning social acceptance, as they tend to interfere with basic human needs like autonomy and privacy (Wolsink 2012). Additionally, market liberalization may reshuffle existing customer utility relationships considerably. Hence, understanding how to secure customers' trust and acceptance is key to a successful transformation of both the Swiss utilities' strategies and the electricity system as a whole (Wolsink 2012; Nyborg and Røpke 2013). In this focus group study (on focus groups, see Kamberelis and Dimitriadis 2013), we analyse residential consumers' attitudes and expectations regarding three scenarios[1] of demand-side management (DSM) and regarding one scenario describing the changing role of utilities in the context of a liberalized market (see scenario descriptions in Table 2).

DSM via dynamic tariffs and direct load control

Palensky and Dietrich (2011, p. 381) define DSM as "a portfolio of measures to improve the energy system at the side of consumption". These include, for one, technological measures that the consumer does not normally notice, like reduction of transmission losses (Fitzgerald et al. 2012) or improved energy efficiency of electric/electronic devices (Palensky and Dietrich 2011). For another—and more interesting from a psychological perspective—there are two measures that directly affect consumers' mental processes and behaviour: time-of-use (TOU) pricing and direct load control (DLC) (Palensky and Dietrich 2011; Fitzgerald et al. 2012).

TOU pricing aims at encouraging consumers to shift their electricity consumption away from periods of high demand ("peak shaving") by "penalizing certain periods of time … with a higher price" (Palensky and Dietrich 2011, p. 382). It can be applied as static tariffs (fixed tariff for each time period) or as dynamic tariffs (real-time market tariffs; Fell et al. 2015). In this study, we focus on *dynamic tariffs*, as this is also the focus of our technological partners within the research programme "Energy Chance".[2] Like Fell et al. (2015), we differentiate between type 1, where smart appliances respond automatically to changing tariffs (*dynamic tariffs—smart appliances*), and type 2, where the consumers themselves have to respond to the tariff information (*dynamic tariffs—manual control*).

DLC allows the electric utility to directly shift loads to periods of lower demand ("load shifting") by remotely controlling electric devices—typically, boilers and heat pumps in households (Murtagh et al. 2014). As DLC may considerably curtail the consumers' autonomy, some DLC systems have a switch so that consumers can manually override the remote control signal from the utility (Fell et al. 2015). In this study, we discuss both types: *DLC—without override ability*; and *DLC—with override ability.*

There exists a considerable body of research on social acceptance of various aspects related to the DSM mechanisms of dynamic tariffs and DLC. EcoGrid EU (2015) found that DLC is more effective than dynamic tariffs for achieving load shifting among residential consumers. Moreover, if applied with override ability, DLC is also more popular (Fell et al. 2015). Nicholls and Strengers (2015) and Murtagh et al. (2014) point to the lack of fairness with TOU pricing: In particular, families with children are constrained in their time-related flexibility in electricity use (e.g. cooking). In terms of dynamic tariffs, automated response by smart appliances finds better acceptance than manual response by the consumer (Fell et al. 2015). However, also DLC has its flaws, as it interferes particularly strongly with individual needs of privacy and autonomy (Murtagh et al. 2014). Acceptance of DLC is also highly dependent on the type of appliance to which it is applied: Whereas DLC is accepted to a certain extent for washing machines, dishwashers, pool pumps and air conditioning, it is seen as out of bounds for television or personal

[1] We understand a scenario to be "a description of possible actions or events in the future" as defined by *Cambridge Dictionary* (Scenario n.d.).

[2] However, some focus group participants brought up static TOU pricing as a solution that might be more feasible than dynamic tariffs (see "Results" section below).

computers (Gardner and Ashworth 2007; Bossi et al. 2013).

DSM via distributed energy storage

Distributed energy storage will play an important role in balancing loads in the future (Mohd et al. 2008; Nguyen et al. 2015; Zheng et al. 2015). This is due to the rapid improvement of storage technologies in terms of cost effectiveness and performance (Parag and Sovacool 2016) and due to the advantages of small-scale, distributed storage systems (e.g. in residential buildings) over large-scale grid-based storage in terms of flexibility (Zheng et al. 2015). Particularly among prosumers (electricity consumers who produce their own electricity), home batteries are becoming increasingly popular (Parag and Sovacool 2016). For prosumers, home energy storage provides the option to store self-produced energy (e.g. via photovoltaic panels, PV), which increases consumers' independence from the grid. And, a majority of prosumers (private PV owners) are willing to place their storage system at the service of the grid operator to balance loads in the grid (Gährs et al. 2015). However, only a small minority of electricity consumers are prosumers.[3] Thus, today, for the majority of electricity consumers, there would be no direct benefit of hosting a home battery at the service of the grid operator. So, as long as utilities charge residential consumers fixed and not TOU tariffs,[4] utilities need to compensate the acquisition and operating costs of home batteries to incentivize consumer participation (Dehamma and Jaffe 2014). We do not know of any research paper that examines the extent to which residential consumers are willing to host a home battery only at the service of the utility (or the grid operator). We formulated a scenario called *energy storage* (see Table 2) and discussed it in the focus groups.

Emergence of novel energy services in Switzerland?

With our fourth scenario, *energy services*, we aim at analysing consumers' attitudes regarding companies providing novel energy services to consumers as a conceivable consequence of a fully liberalized electricity market.

In 2007, the Swiss parliament passed the Power Supply Law, which provides for a two-step market liberalization process: liberalization for large consumers (>100,000 kwh/year) in 2009 and for small consumers in 2014. However, due to a still pending energy treaty with the EU and ongoing negotiations at the national level, the second step has not yet been implemented. The government has announced that after a thorough situation analysis, it will propose a new proceeding on the issue to the parliament in 2017 (Federal Department of the Environment, Transport, Energy and Communications 2016).

In Switzerland, approximately 900 companies are involved in direct or indirect electricity supply to end users. About 800 of them are local or regional distribution system operators (DSOs) that provide all end users in their supply zone[5] with electricity (Swissgrid 2017). As the electricity market is regulated for end users with consumption of less than 100,000 kwh/year, DSOs can charge them tariffs that cover production costs and a profit margin.[6] However, electricity generation companies with no end users have to sell their electricity to the wholesale market, where prices are currently lower than the generation costs. Hence, the second step of market liberalization could have considerable financial consequences for DSOs, as opposed to electricity generation companies with no end users, if they stick to their conventional business models.

The market liberalization will give new companies the opportunity to enter the market. In the context of the trending digitalization of the economy in general (Loebbecke and Picot 2015) and the energy sector in particular (Booth et al. 2016), this emerging market may be especially attractive for companies with expertise in telecommunications or information technology (IT). These companies could leverage their expertise to provide residential electricity consumers with novel energy-related services (e.g. energy trading platform

[3] In Switzerland in 2015, only 1.2% of the produced electricity stemmed from solar energy (Federal Office for the Environment 2016).

[4] In Switzerland, for example, utilities usually fix a high rate for daytime hours and a low rate for nighttime hours.

[5] Licences for supply zones are granted by cantonal (state) and communal (communes are the smallest political unit in Switzerland) authorities.

[6] Tariffs are monitored by ElCom, Switzerland's independent, federal regulatory authority. ElCom may prohibit unjustified electricity price increases or reduce excessively high tariffs (ElCom 2017).

for prosumers, smart home solutions), which established actors in the energy market have not offered so far. Thus, if established actors want to stay competitive, they will have to provide novel energy services as well.

For the consumers, this trend means that energy service providers—their DSOs or new players in the market—will offer new services. A resulting benefit could be an attractive choice of energy service offerings. However, if big companies (e.g. telecommunications or IT) also act as energy service providers, consumers could feel uneasy, as now several life domains would be in the hand of one powerful company.

Research questions

The following research questions guided our analysis:

First, what do Swiss residents think about the DSM mechanisms *dynamic tariffs* and *direct load control*? What are the drivers of and barriers to their acceptance?

Second, what do Swiss residents think about hosting a *home battery* as a means to contribute to grid stabilization? What are the drivers of and barriers to its acceptance?

Third, what do Swiss residents think about novel *energy services* and the changing role of utilities in a liberalized electricity market?

Methods

Recruitment of participants

Six focus groups participated in guided discussions between February and June 2016. Two focus groups consisted of private energy consumers in general living in the German-speaking part of Switzerland, and four focus groups were private customers of two regional power utilities specifically. Focus group participants were recruited via electronic bulletin boards of the utilities, personal letters to a randomized sample of the utilities' customers, advertisements in a local newspaper and word of mouth. In a first step, all interested persons were screened in a telephone interview for general eligibility (i.e. *minimum* level of articulateness, availability, involved in household decisions).

All eligible participants filled in a short questionnaire that asked about age, gender, home ownership, ownership of private energy installations (prosumers) and environmental awareness (measured using Dunlap et al.'s (2000) revised NEP scale). For a broad range of opinions in all discussions, the participants were assigned to heterogeneous groups in terms of age and gender (see Table 1 for groups and group characteristics). Participation was incentivized with 100 Swiss francs (ca. 90 euros) per person and with provision of food and beverages.

Focus group discussions: Procedure and materials

General procedure

Participants were summoned 15 min prior to the start of the focus group discussions. They were welcomed by the moderator and the assistant moderator and subsequently asked to sign a consent form.[7] The discussions lasted 2 h, with a 15-min break after the first hour. After the discussions, participants received 100 Swiss francs, signed a receipt, and left.

Discussion sections

A moderator led the discussion following a semi-structured script. The guided discussion was divided into four sections: (1) general introduction and preview of procedure by the moderator (5 min), (2) individual experiences and expectations regarding the electricity supply as of today (20 min), (3) attitudes and expectations regarding four presented scenarios of future customer/utility interactions (75 min, suspended for a 15-min break after 30 min), and (4) wrap-up by the moderator and completion of a short questionnaire (15 min). The four sections are described in more detail in the following.

In discussion section 1, the moderator welcomed the participants to the focus group and provided information on the context of the focus group study (research goal, funding, institutes and persons involved). The moderator then gave a preview of the procedure of the discussion (i.e. the four sections) and reminded the participants to follow a number of rules of conduct (Kamberelis and Dimitriadis 2013).

Discussion section 2, on the participants' present interaction with the utility, began with three rather general questions to encourage active participation also

[7] Contents of the consent form (a) study background, general procedure for the discussion, and (b) conditions of study participation.

Table 1 Sample characteristics

Group no.	Composition	Date	Number (males)	Mean age	Mean NEP score (1 = low, 5 = high)	Number of home owners	Number of prosumers
1	General public	24.02.16	7 (3)	38.0	3.9	3	1
2	General public	23.03.16	9 (4)	30.2	3.5	5	0
3	Customers utility A	17.05.16	9 (7)	46.6	3.4	8	1
4	Customers utility B	18.05.16	13 (11)	65.7	3.5	10	0
5	Customers utility A	30.05.16	9 (7)	51.1	3.0	5	1
6	Customers utility B	01.06.16	8 (8)	60.4	3.6	6	1

among timider participants (*What role does electricity play in your everyday life? How would you describe your relationship with your electricity provider? What do you expect from your electricity provider?*). To prepare the participants for the discussions on dynamic tariff models that followed in section (3), the moderator showed a picture of an electricity bill and encouraged the participants to talk about the meaning of the various clearing items of the bill.[8]

In discussion section 3, the four scenarios of future utility/customer interaction were discussed: dynamic tariffs, DLC, energy storage and energy services (see Table 2). First, the moderator introduced the participants to the problem of intermittent loads, which results from an increasing share of renewable energies in the electricity grid. Two stimuli on Microsoft PowerPoint slides were used to help explain the intermittency problem. The first slide showed a typical demand curve for 24 h in Switzerland, which also showed how the different available energy sources contribute to meeting this demand (see Fig. 1). A second slide showed a hypothetical variation of this demand curve that assumed that the demand was supplied by only (highly unsteady) solar and wind power (see Fig. 2). Participants were then encouraged to suggest possible solutions for the intermittency problem, which the moderator wrote on a flip chart. To help the participants focus on solutions that involve human behaviour (as opposed to technological solutions alone), the moderator asked specifically: *How would you solve this problem? How could electricity consumers contribute to the solution of the problem? How could electricity consumers be encouraged to do the right thing in the crucial moment?*

After that open discussion of the suggestions, the remainder of discussion section 3 focused on evaluation of the four scenarios (see Table 2), which were presented to the participants as diagrammatic plans on posters (size DIN A1) (see Figs. 3 to 5) and explained verbally. The moderator asked the following questions: *What do you think of this idea? What are the benefits and the disadvantages related to it (when you relate it to your everyday life)? Under what conditions would you be willing to accept this [tariff model, load control option,* etc.*]?*

After the separate in-depth discussion of all scenarios, participants were invited to rate each scenario by attaching a coloured sticker to the poster. The colours allowed the participants to choose from three levels of acceptance: red = "I would not accept the scenario under any circumstances", yellow = "I would accept the scenario if certain conditions were met" and green = "I would fully accept the scenario".

After the participants had rated the scenarios, the moderator encouraged them to discuss the issue of privacy: Several of the scenarios that we have discussed contain communication technology that enables data exchange between household and the utility: What feelings does this trigger in you? What do you expect of the utility concerning this matter?

In discussion section 4, while the participants were filling in a short (mainly) socio-demographic questionnaire, the moderator summarized the most important statements from the discussion, which he subsequently presented to the participants. The moderator then thanked the participants and closed the discussion.

[8] In Switzerland: tariff per kilowatt hour, sum of kilowatt hours (subdivided into daytime and nighttime tariff), charges for use of the grid, and public charges related to grid use.

Table 2 Scenarios and subtypes describing future customer/utility interactions

Scenario/subtype	Description
Dynamic tariffs	
Smart appliances	Utility sends price signal to smart appliance (e.g. heating) every 5 min. Consumer defines price limits. Appliance starts or stops running after matching actual price signal with predefined price limits.
Manual control	Utility sends price signal (actual price and forecast) to web server every 5 min. Consumer checks price and forecast via smartphone. Consumer starts or stops appliances directly or via remote control (e.g. smartphone).
Direct load control	
Without override ability	Utility controls appliance directly via remote access, complying with the terms of the contract. Consumer has no means to override the direct control by the utility.
With override ability	Utility controls appliance directly via remote access, complying with the terms of the contract. However, the consumer can override the direct control by the utility.
Energy storage	Utility provides home battery (size of a small fridge) and cares for its maintenance. Consumer provides space for the battery e.g. in the garage.
Energy services	Utility provides customer-oriented energy services (e.g. adequate room temperature and warm water, eco-friendly mobility, enabling micro generation, etc.) instead of selling plain units of energy.

Description of the scenarios

The four scenarios (see Table 2) were presented without defining many details. This approach was chosen to help the participants focus on the main idea of the scenarios, instead of getting into discussions on technical details.

In the *Dynamic tariffs scenario* (see Fig. 3), tariffs follow the logic of supply and demand. That is to say, they rise with increasing demand and/or decreasing supply, and they fall with decreasing demand and/or increasing supply. Two subtypes of the scenario were discussed separately: *Dynamic tariff—smart appliances*; and *Dynamic tariff—manual control*. In the *Dynamic tariff—smart appliances* type, the utility sends price signals to the household, where smart appliances receive the signal and react according to settings previously defined by the resident. The settings consist of a price limit below which a certain appliance can run and a time range within which the price limit applies. When a price signal matches the defined criteria, the appliance starts automatically. The scenario did not explicitly define exact criteria for an appliance to stop running or define the appliances to which the mechanism applies. In the *Dynamic tariff—manual control* type, the price signal from the utility is not received by smart appliances but can be looked up (together with a price forecast) by the consumer on a website or via a smartphone app. On this basis, consumers decide at what time they want to use household appliances. In this scenario subtype, consumers can switch their appliances on and off remotely via smartphone.

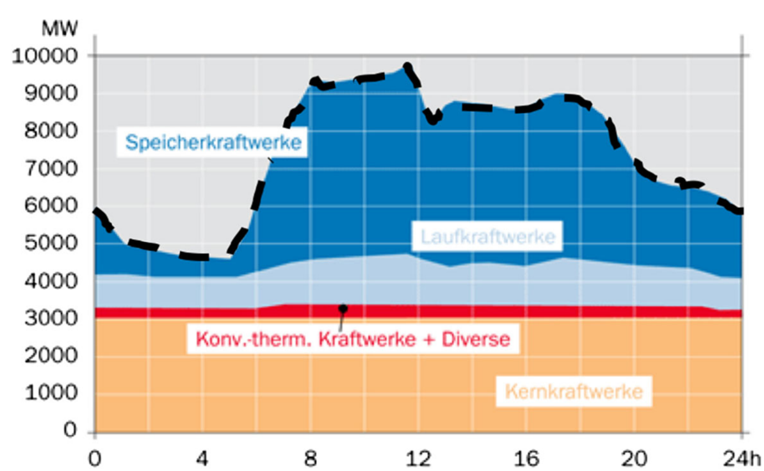

Fig. 1 Microsoft PowerPoint slide used as stimulus: actual demand curve in Switzerland within 24 h (*dashed line*) and shares of energy sources meeting demand (from the *bottom up*: nuclear, conventional thermic and others, river hydro, pumped storage hydro). From Verband Schweizerischer Elektrizitätsunternehmen VSE (2016), with kind permission of VSE

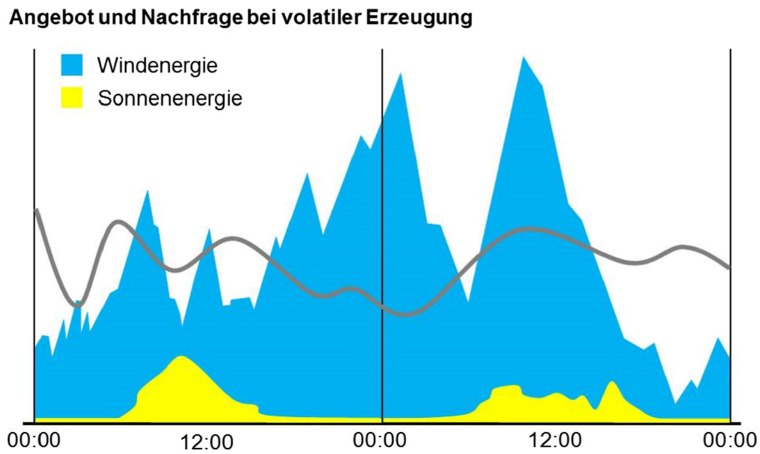

Fig. 2 Microsoft PowerPoint slide used as stimulus: hypothetical demand curve in Switzerland within 48 h (*grey line*) and hypothetical energy supply by wind and solar power (assumption: only wind and solar are available)

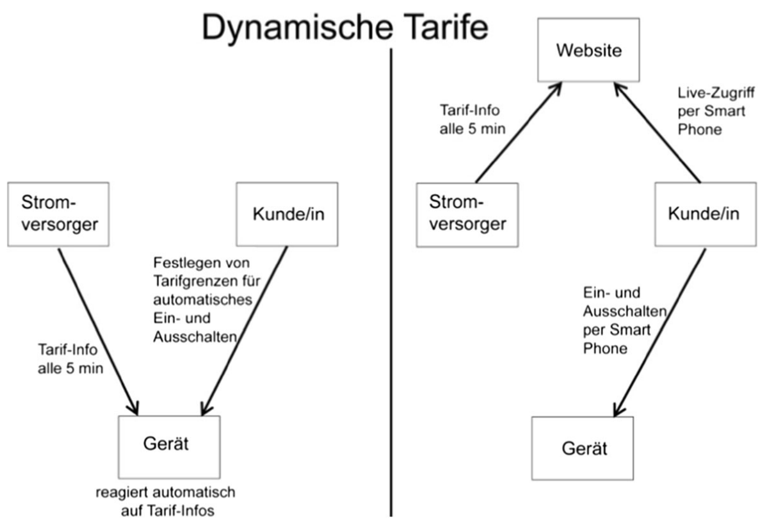

Fig. 3 Poster showing dynamic tariffs scenario. “Dynamic tariff—smart appliances” (*left*). “Dynamic tariff—manual control” (*right*). Original size: DIN A0

In the *Direct load control scenario* (see Fig. 4), the utility can—within the terms and conditions of a contract—switch household appliances on and off remotely. The two subtypes *without override ability* and *with override ability* differed as to whether the consumer has the option to override the remote control from the utility.

In the *Energy storage* scenario (see Fig. 5), the utility maintains a home battery in the consumer’s garage or basement, and in the *Energy service* scenario (see Fig. 5), utilities act as providers of a broad range of customer-oriented energy services.

Data analysis

All focus group discussions were audio-recorded and transcribed. As the discussions were conducted in Swiss German, they were translated into standard German during transcription.[9] The discussion section with evaluation of the four scenarios was analysed following Mayring’s (2008) content structuring method, using the software MAXQDA 12. The following describes the four steps of our analysis process (see also Fig. 6):

Step 1 *Allocation of statements to scenario categories.* Initially, we defined units of analysis: Every statement containing substantial information about one of the scenarios was a single unit of analysis. On that basis, two coders assigned all statements to one of the four scenarios.

[9] In the German-speaking part of Switzerland, the language commonly spoken is Swiss German; however, standard German is always used for written documents.

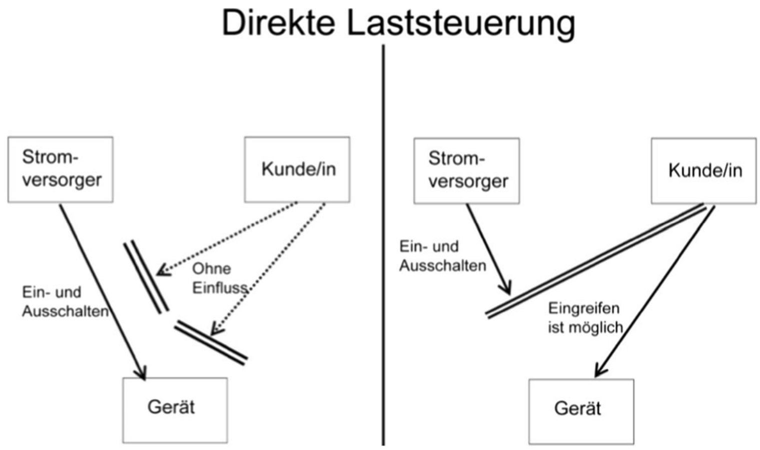

Fig. 4 Poster showing direct load control scenario. "Direct load control—without override ability" (*left*). "Direct load control—with override ability" (*right*). DIN A0

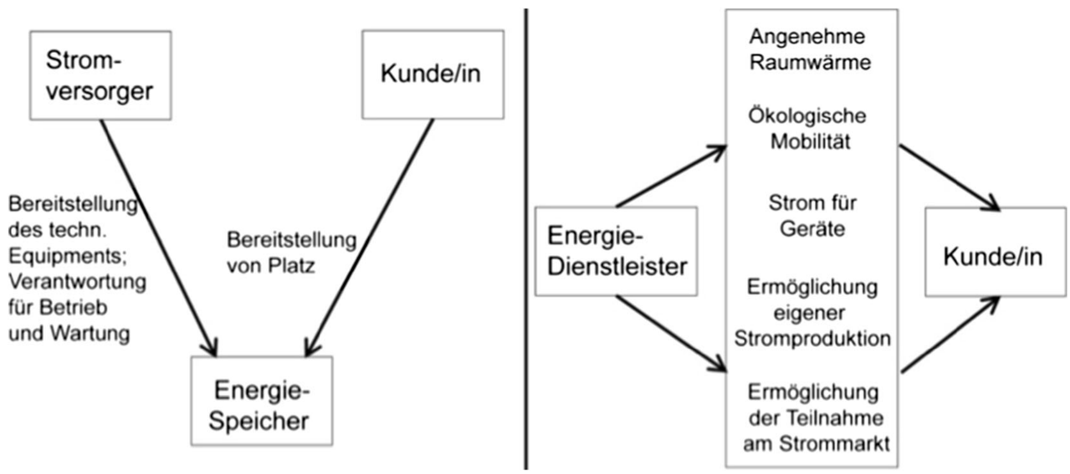

Fig. 5 Posters showing scenario "Energy storage" (*left*) and "Energy services" (*right*). Each DIN A1, presented separately

Statements on dynamic tariffs or DLC were assigned to the respective subtype. Statements which referred to dynamic tariffs or DLC, but did not refer to one of the subtypes, were assigned to the scenario category *Dynamic tariffs—general idea* or to *DLC—general idea*, respectively (see Table 3, first column).

Step 2 *Allocation of statements to valence categories.* In this step, the two coders assigned the statements to one of the three following valence categories: positive statement on scenario, neutral statement on scenario and negative statement on scenario.

Step 3 *Development of argument categories.* To find out more about the arguments that underlie the valence regarding a scenario, all statements were analysed by following Mayring's (2008) content structuring method. This means that the statements were paraphrased first and generalized thereafter. The result of the generalization process was thematic argument categories for each of the scenario categories of Table 3. The thematic argument categories represent different types of reasons why persons would agree or disagree with a certain scenario. For example, the statement "Actually, to me, the scenario seems too time consuming" on dynamic tariffs—manual control (step 1)—was coded with a negative valence (step 2). In step 3, it was generalized to "scenario is too time consuming", and the coder created a category named "too time consuming". Other examples for argument categories are "fairness", "type of appliance" or "sustainability". All argument

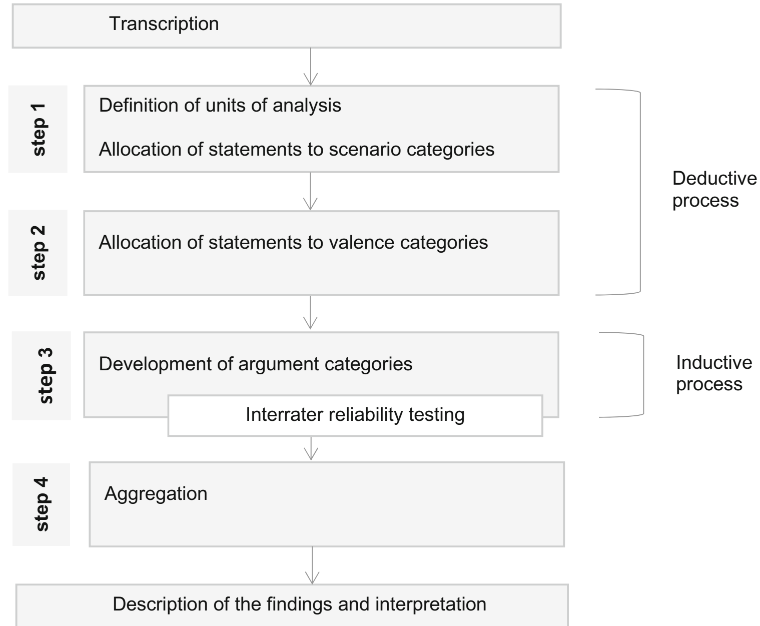

Fig. 6 Qualitative analysis process

categories and their definitions are listed in the appendix.

To evaluate the reliability of the analysis, we tested for interrater reliability in step 3. To this purpose, after one coder had created the argument categories inductively, the other coder then related the statements to the argument categories.

This allowed us to calculate to what extent the two coders agreed on the assignments of each statement to an argument category. We calculated Cohen's kappa as an indicator of interrater reliability for the total 24 sets of statements. The results (Table 3) show that Cohen's kappa reaches values between "substantial agreement" (κ > 0.61) and "almost perfect agreement" (κ > 0.81) (Landis and Koch 1977) in all sets except energy services.

Table 3 Interrater reliability in step 3

Arguments						
	Pro		Neutra		Contra	
Scenario/subtype	N_c	κ	N_c	κ	N_c	K
Dynamic tariff—general idea	8	0.85	11	0.9	10	0.74
Dynamic tariff—smart appliances	17	0.72	17	0.8	51	0.73
Dynamic tariff—manual control	11	0.78	6	0.75	38	0.81
Direct load control—general idea	11	0.63	8	0.86	8	0.83
Direct load control—without override ability	23	0.62	13	0.68	23	0.76
Direct load control—with override ability	7	0.67	2	1	24	0.66
Energy storage	29	0.6	48	0.74	48	0.71
Energy services	20	0.58	35	0.67	29	0.59

Landis and Koch (1977) suggest the following values: <0 = poor agreement, 0–0.20 = slight agreement, 0.21–0,40 = fair agreement, 0.41–0,60 = moderate agreement, 0.61–0,80 = substantial agreement, 0.81–1,00 = (almost) perfect agreement

N_c number of codings, κ Cohen's Kappa

Step 4 *Aggregation.* The researchers printed out all statements on separate sheets per argument category and hung them up in a meeting room to obtain an overview of the categorized data. Together, they aggregated the argument categories into broader meta-categories.

Results

The results are presented in this section in accordance with the structure of the discussion script—that is, in the following order: results regarding customers' present interactions with their utility ("Participants' perceptions of their present utility interactions"), participants' reactions to the four scenarios ("Dynamic tariffs scenario", "Direct load control scenario", "Energy storage scenario" and "Energy services scenario") and participants' opinions on the important cross-sectional topic of data privacy ("Discussion on privacy issues").

Participants' perceptions of their present utility interactions

As exemplarily shown by quote Q1, most consumers perceived their current interaction with their utility as ordinary and unimportant, as long as a constant electricity supply was ensured. Some consumers insisted on being provided with unambiguously labelled sustainable electricity (Q2), but others expressed only very basic expectations, such as a constant electricity supply (Q3).

Q1: In my case [the relationship is] also rather passive, only when I receive the bill, and apart from that, I never have any contact[10] (focus group (FG) 5).

Q2: Well, I simply expect to receive ecological electricity. I prefer electricity that originates from air and light, [electricity] that is not causing any damage (FG 2).

Q3: For me personally, it is more important that continuity is ensured, that there is no blackout (FG 2).

Q4: I would like to be informed about the available electricity products more proactively. Of course, I myself could actively update; however, it would be nice if I received additional information with my electricity bill (FG 1).

Q5: What I really appreciate is the summary on the bill, how much you have saved or how much your consumption has increased since the last time. I think this is useful information (FG 6).

Many consumers called for better communication on the part of the utilities. They wished that they communicated more frequently and in a more consumer-oriented way (Q4). Highly appreciated information (which some utilities are already providing on the yearly electricity bill) was the comparison of electricity consumption from year to year. Information of this kind was expected to help consumers reflect upon their consumption and thus reduce it (Q5). However, some participants suggested that the consumption information on the bill should be more easily understandable i.e. should be shown in diagrams. Additionally, consumption data reported separately per appliance was also seen as an interesting option. However, related to this idea, participants expressed concerns regarding privacy issues.

Dynamic tariffs scenario

A first impression of how participants perceived the two subtypes of the dynamic tariffs scenario was provided by the results of the sticker ratings (see Table 4). Of a total of 55 ratings of the scenario subtype "Dynamic tariff—smart appliances", 37 were either yellow or green, meaning that 67% would accept the subtype "Dynamic tariff—smart appliances" as presented in the focus group or if certain conditions were met. In contrast, only 40% would accept (again, green and yellow stickers) "Dynamic tariff—manual control".

The following were the most prominent arguments for and against "Dynamic tariff—manual control" (derived in step 4 of the analysis), representing the participants' key attitudes and expectations regarding the scenario:

Q6: *This is only something for absolute enthusiasts* (FG 4).

Q7: *Imagine my employer, if I have to switch appliances at home on and off during half of my working time* (FG 6).

Q8: *After all, I think, you need to have a smartphone, I mean, a touch screen and you need Internet. I think that's problematic* (FG 2).

Participants generally saw manual monitoring of tariffs with remote manipulation of devices (e.g. via smartphone) as too complicated and time-consuming (Q6 & Q7). Not only elderly persons in particular expressed scepticism, but also younger participants

[10] Original quote. All quotes from the discussion participants were translated from German into English for this paper by the first author.

Table 4 Sticker ratings: count of red, yellow and green stickers per focus group and scenario

Focus Groups	1	2	3	4	5	6	Sum	%
Dynamic tariff—smart appliances								
Red	0	2	1	5	7	3	18	32.7
Yellow	1	2	7	6	1	3	20	36.4
Green	6	5	1	2	0	3	17	30.9
Sum	7	9	9	13	8	9	55	100.0
Dynamic tariff—manual control								
Red	0	4	0	13	8	7	32	60.4
Yellow	2	3	6	0	0	0	11	20.8
Green	5	2	3	0	0	0	10	18.9
Sum	7	9	9	13	8	7	53	100.0
Direct load control—without override ability								
Red	5	7	6	8	6	5	37	66.1
Yellow	2	2	2	2	1	1	10	17.9
Green	0	0	2	5	0	2	9	16.1
Sum	7	9	10	15	7	8	56	100.0
Direct load control—with override ability								
Red	0	3	0	0	0	3	6	11.1
Yellow	1	3	4	7	3	3	21	38.9
Green	6	3	5	6	5	2	27	50.0
Sum	7	9	9	13	8	8	54	100.0
Energy storage								
Red	1	1	1	1	1	0	5	9.1
Yellow	1	6	3	8	1	4	23	41.8
Green	5	2	5	6	6	3	27	49.1
Sum	7	9	9	15	8	7	55	100.0
Energy services								
Red	1	1	1	0	0	3	6	10.9
Yellow	4	4	7	1	0	3	19	34.5
Green	2	4	1	13	8	2	30	54.5
Sum	7	9	9	14	8	8	55	100.0

pointed out that the scenario may discriminate against citizens with low digital literacy (Q8).

Although generally better accepted, the "Dynamic tariff—smart appliances" subtype was also criticized. Again, participants perceived the scenario as complicated. However, they suggested that a tariff system with broader tariff periods (e.g. five daytime tariffs and two night-time tariffs instead of the suggested periods of 5 min) might be acceptable. Additionally, participants made it clear that only a few appliances with high consumption and whose use is not bound to a certain time of the day (e.g. heating, boiler, washing machine, tumble dryer) were suitable for being used as "smart appliances". It seemed unclear how big the effort of procuring appliances compatible to each other and to an overarching system (e.g. smart home environment) would be (Q9). Participants pointed out that their scepticism rooted mainly in the lack of details defined in the scenario: To be able to accept the scenario fully, participants needed more details (Q10). Due to this lack of clarity, many kinds of concerns arose in the participants' minds, such as the idea that appliances might be switched off when they should not be (e.g. the oven, while baking something). For one, these concerns seemed to be rooted in a lack of confidence in the reliable functioning of control algorithms of future smart appliances. For another, the scepticism might stem from a lack of trust in the companies (e.g. utilities) providing and managing such smart appliances.

Q9: *[It's not feasible] if in any appliance a receiver modem or something has to be integrated* (FG 3).

Q10: *Well, for me there's the question regarding the fine print in the contract. I like the idea as such, however, what does it [mean] precisely…?* (FG 4).

Q11: *Actually, it's a gimmick, and regarding the technology I think it's fascinating…* (FG 5).

Q12: *Additionally, I can imagine that such a device could also be able to provide feedback, in terms of how much electricity […] it really takes* (FG 1).

Although participants considered the idea of reducing energy consumption via dynamic tariffs reasonable from a general point of view, some of them pointed out that the currently low electricity prices might inhibit the intended effect. This notion could be an explanation of why in the EcoGrid Project (EcoGrid EU 2015), the effect of dynamic tariffs was very low.

Participants brought up the issue of fairness, referring to the fact that time-related flexibility in the use of appliances is not equally distributed among consumers. Some households (e.g. with children; as also shown by Nicholls and Strengers 2015) are bound to certain hours (e.g. cooking dinner around high demand hour of 6 p.m.), while others (e.g. singles) could shift their consumption more easily to less expensive hours. In this context, one group came up with the idea of introducing a quota for low-priced electricity for "basic electricity needs". After the exhaustion of this quota, electricity would still be available—but at a higher price, however.

For some of the participants, the idea of dynamic tariffs was appealing, as it involves innovative technology (Q11). Participants also linked the technology involved to the concept of a smart home environment (see Harper 2006). And, some participants mentioned additional beneficial features of technology of this kind, such as feedback on electricity consumption (Q12).

Finally, the discussion on dynamic tariffs stimulated other interesting ideas among participants. First, it was suggested that new services could be offered to consumers around their management of dynamic tariffs. If consumers do not have enough time, are not interested in or are incapable of managing their energy consumption in the context of dynamic tariffs, new service providers could offer them help in optimizing their consumption patterns. Second, it was argued that dynamic tariffs could be of use for consumers, if they were combined with the option to store energy. In this case, consumers would be less dependent on high-priced grid electricity in the case of urgent demand.

Direct load control scenario

The stickers rating showed that only 34% of the participants would accept the "Direct load control—without override ability" scenario subtype as presented in the focus group or if certain conditions were met. Hence, most participants rejected direct load control, if the consumer does not have the possibility to override the control from the utility. On the other hand, 89% would accept (again, green and yellow stickers) "Direct load control—with override ability".

Q13: *It depends on the type of appliance. If you deactivate kitchen appliances at lunchtime, one would be restricted, that's clear. However, the washing machine does not need to run at lunchtime.* (FG 3).

Q14: *Well, I want to keep a minimal level of influence. […] I do not want to virtually issue a blank cheque.* (FG 4).

Q15: *[…] I do not trust the consumers enough. Because I assume that such exceptions would not stay exceptions, instead they would become the rule.* (FG 1).

There was broad consensus among participants that direct load control was only acceptable for a certain type of appliances (Q13). Whereas it was seen as acceptable for appliances like boilers, heat pumps or washing machines (their use for the consumer is not strictly bound to a specific time of the day), for appliances with more time-specific use (e.g. stove, TV), direct load control was seen as unacceptable.

Although in its basic form direct load control has been common practice for decades (e.g. boilers), it affects consumers' needs of autonomy and privacy (Q14). Participants suggested that utilities should be sensible to these customer needs and emphasized the importance of transparently communicating contract details before a contract is signed. As in the case of dynamic tariffs, participants raised concerns regarding fairness. Not all citizens dispose of the same possibilities regarding load shifting; persons working night shifts, for example, might need to use the washing machine during morning hours.

The option to override utility signals was generally seen as crucial for the acceptance of direct load control, but some participants raised doubts about whether the targeted energy savings would be realized, if the exception of overriding became the rule (Q15). Some of the focus groups discussed whether it would be fair to charge the customer for the ability to override the utility signal. Participants argued not only that this could circumvent too frequent overriding but also that the overriding fee could be too high, which in turn would question the social fairness of such a system.

Energy storage scenario

The stickers rating shows that 91% of the participants would accept the "Energy storage" scenario as presented in the focus group or if certain conditions were met. Moreover, energy storage as a solution for intermittency related grid problems had often been suggested spontaneously in the discussions before the scenario was presented. Hence, the idea of employing energy storage was highly appreciated, and the evolving battery technology (smaller, less expensive, safer) was seen as a catalyst for deployment of this solution.

Q16: *For me it would be feasible if the battery did not feed electricity back into the grid but provided the electricity only for the customer* (FG 4).

Q17: *Well, would it be left to the customer to decide to use electricity from the battery or from the grid? […] It should only be drawn from the battery when there is not enough. Otherwise it does not make sense* (FG 2).

Q18: *When you get home after going out, you can still put a pizza in the oven [although supply has been switched off by the utility], as you can switch to the battery* (FG 2).

Additionally, participants suggested that Swiss manufacturers could take a leading role in battery development and thus benefit from this trend. However, in all focus groups, it was suggested that it would make more sense to install larger (semi-)centralized energy storages (i.e. one per residential area; or at transformer stations) than small storages in households. The reason behind this suggestion was safety concerns (fire hazard, poisonous fumes), ecological concerns (embodied energy, safe disposal) and doubts regarding the cost-value ratio of household storages. Some participants expressed the reminder that the energy drawn from storage is only as green as the energy put in it beforehand, and they therefore stated that they would expect utilities to store only "green" energy in them.

Regarding the question of whether household consumers should be able to use the energy of their household storages autonomously, opinions diverged. On the one hand, some participants argued that the right to dispose of the stored energy would—besides monetary compensation—be the only motivation to accept energy storage in one's household (Q 16). On the other hand, some participants doubted that the intended load shifting would be effective enough without well-coordinated use of the household storages (Q17). Thus, these participants suggested the implementation of a clear set of rules on how and when the use of one's own stored energy was allowed.

The most highly appreciated use of household storages was seen in households that produce their own renewable energy (e.g. photovoltaics or small-scale wind turbines). Household storages were finally considered very useful as a means to mitigate unwanted effects of dynamic tariffs or direct load control (Q18).

Energy services scenario

Here, the stickers rating shows that 89% of the participants would accept the "Energy services" scenario as presented in the focus group or if certain conditions were met.

Q19: *Maybe you just get a bundle [of services] like the one you get at [telecom provider] and they tell you which services they give you, and then you lose track of it* (FG 2).

Q20: *There must be a certain obligation to inform the customer. Then you can speak of partners on an equal footing, so there will not be an imbalance, and in the end they cannot say* "*It's sink or swim*". *In my opinion, this should be part of this kind of energy service* (FG 4).

However, this broad acceptance was linked to the stated condition of transparent communication by the utility. Without such communication, participants would not trust the utility (especially if privately owned) in view of two main concerns: First, the utility might sell the customer a bundle of services, of which some may be of no use to the customer (Q19). Second, handling of sensitive data by the utility was seen as critical, as with expanding services, and utilities might gather and merge data from various life domains.

Generally, if the utility exerted control in too many domains at the time, it could become too powerful. Hence, on several occasions, participants emphasized the importance to treat customers as responsible citizens and to give them the opportunity to make their free decisions (Q20).

Environmentally conscious participants see services of this kind as an opportunity for utilities to act as facilitators of green behaviour, as energy-saving practices could be supported as well as micro-generation (i.e. wind, photovoltaic).

Customers of the two partner utilities appreciated already existing services that go beyond simple electricity supply (e.g. regional charging stations for electric vehicles, energy consulting for residential construction projects, contracting for heating and cooling).

Discussion on privacy issues

The discussion on privacy issues in the focus groups was less critical than we had expected based on our review of the literature (e.g. Döbelt et al. 2015; Accenture 2010). However, the topic of privacy issues has the potential to stimulate strong emotional reactions, as it was the case in focus group 2 (Q21).

Q21: *[…] I mean data can be used in a lot of ways, yet Hitler had noticed that […] That's just how it is. And especially regarding this open amount of data, a lot can be read out.* (FG 2).

Q22: *I have the feeling that at other places I am more under surveillance, where I would feel more uncomfortable about it.* (FG 3).

Q23: *That's my concern, it is an ethical concern, not that I had something to hide—it's just a sheer ethical concern.* (FG 3).

Q24: *My trust in [utility B] is based on the fact that it is owned by the municipality […] If it was run privately by a company instead, I would not…* (FG 4).

Overall, there was a consensus that the utility has to guarantee data security (no data should be made available to third parties). Regarding data made available to the utility, opinions diverged. Some participants argued that data on energy consumption are not very sensitive in comparison to other types of data (i.e. health data) and that consumers to date already share a lot of data (e.g. via social networks, loyalty cards) (Q22). However, participants also pointed out that privacy has to be protected from an ethical point of view (Q23). In the discussions, a consensus was found in the demand that making data available to the utility should not be mandatory. Instead, it should be the consequence of a deliberate decision by the customer.

Besides the negative aspects of data generation and collection, some participants argued that the energy consumer could also benefit from the collected data. That is to say, consumers provided with data on their consumption could use such data to save energy. It was also mentioned that if customers who provide consumption data in a liberalized market are not remunerated in an adequate form—as it is the case with loyalty cards—they will look for another utility that offers more attractive remuneration.

In this context, the topic of trust was again very prominent. Consumers were willing to provide data only to trusted utilities. The customers of utility B assumed that as long as their utility is publicly owned, trust will be generally high. However, they had concerns that severe financial pressure might also tempt their utility to convert customer data into monetary value.

Discussion

Summary and interpretation of the results

At the end of the introduction section above, we formulated three research questions. The first research question was *What do Swiss residents think about the DSM mechanisms dynamic tariffs and direct load control (DLC)? What are the drivers of and barriers to acceptance?* Our findings are mostly consistent with the findings in other countries. As in Fell et al. (2015) in Great Britain, DLC with override ability and dynamic tariffs with smart appliances is generally better accepted than DLC without override ability and dynamic tariffs with manual control. We found that for both dynamic tariffs and DLC, the level of acceptance depends on the type of appliance to which it is applied: For appliances where use is not bound to a certain hour (e.g. boiler, washing machine, heat pump), it is considered acceptable; for others (in particular kitchen appliances), it seems to be a no-no. Bossi et al. (2013) reported similar findings regarding DLC in Italy, as did also Gardner and Ashworth (2007) in Australia.

Our second research question was *What do Swiss residents think about hosting a home battery as a means to contribute to grid stabilization? What are the drivers of and barriers to acceptance?* The idea of distributed energy storage in the form of home batteries turns out to be very popular among the participants. This popularity seems to be fueled at least in part by a fascination with the technology involved. However, residents have to be incentivized either with a financial premium or by giving them, at least to some degree, the option to draw energy from their "own" battery. Concerns regarding safety (i.e. fire hazard and toxic fumes) and environmental issues (i.e. embodied energy and safe disposal) are widespread among the participants and could pose a barrier to the roll out of home batteries. At least the safety concerns could be circumvented by (the repeatedly suggested) alternative of semi-centralized batteries (e.g. one per residential area or at transformer stations; see also Dehamma and Jaffe 2014).

Besides being seen as particularly valuable for prosumers (see Parag and Sovacool 2016), distributed energy storage is judged to be a means that could be applied as a complement to dynamic tariffs or DLC. In a context of dynamic tariffs or DLC, residential consumers might even be willing to bear a part of the costs of a home battery. An economic study evaluating the business case for distributed home batteries as a DSM means in Switzerland would therefore be of high value.

The third research question was *What do Swiss residents think about novel energy services and the changing role of utilities in a liberalized electricity market?* The idea of customer-oriented energy services is generally appreciated. However, transparent communication of the terms and conditions for the novel services is crucial for a trusted relationship. Participants appreciate new players in the market, since they come with innovative ideas. But, new players have to gain the customers' trust first, because—unlike the established utilities—they cannot benefit from ties that are based on regional identification. In response to the idea that players from telecommunications or IT could enter the market, some participants express concerns regarding data privacy. However, in general, the participants express less data privacy concerns than we had expected (e.g. Döbelt et al. 2015; Accenture 2010).

Practical implications

While dynamic tariffs with manual control and DLC without override ability can be ruled out as suitable DSM mechanisms, dynamic tariffs with smart appliances and DLC with override ability could be considered by utilities if they are applied within a simple, fair and clearly communicated set of rules. Particularly promising in terms of acceptance is the combination of distributed energy storage and DLC with override ability. However, the following aspects have to be taken into account when implemented: Keep terms and conditions simple, minimize the safety and environmental risks of battery, provide a financial incentive, and offer a fair ruling regarding use of battery energy by consumers.

As the analysis showed, the needs of the residential consumers are diverse. Consumers differ in the effort that they are willing to put into daily decisions regarding energy consumption and in their willingness to support specific practices. Thus, utilities could benefit from offering target-group-specific services and communication. Still, for the vast majority of consumers, electricity consumption is a low-interest topic (see Accenture 2010; Throndsen 2017). For them, the services offered have to be simple and associated with the least effort possible.

Conclusions

The method of focus group discussions allowed us to conduct an in-depth analysis of the multifaceted topic of future utility/customer interactions in a transforming energy system in Switzerland. We hope that our findings will assist Swiss utilities in developing DSM and market strategies that match the need of their customers and will eventually contribute to a successful transition into a clean and safe energy system. Although we studied the Swiss energy system—where the market liberalization process lags behind most European countries—our findings can be generalized to other national contexts, as the need for DSM solutions is internationally on the rise due to rapid technological developments and an increasing share of renewables in the grids.

However, there are some limitations to consider. First, it is important to emphasize that although we presented some quantitative data, this is a qualitative study. Thus, the presented results cannot claim to be representative. Second, despite the generous incentive of 100 Swiss francs, persons with a specific interest in energy topics were overrepresented in the six focus groups (self-selection bias), as were also men and senior citizens.

A quantitative follow-up study is currently being conducted to replicate and extend the findings on a representative empirical basis, a large-scale online survey with a special focus on customer segmentation among the customer base of the two regional partner utilities. We further consider distributed energy storage as means of DSM a promising research topic—as a stand-alone solution or in combination with DLC. The topic could be approached from a multi-disciplinary viewpoint integrating technological and organizational challenges, factors of social acceptance and the identification of possible business cases.

Compliance with ethical standards

Conflict of interest The authors declare that there are no conflict of interest.

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