Smart energy systems in private households: Behaviors, needs, expectations, and concerns

Erion Elmasllari
Fraunhofer FIT
Schloss Birlinghoven
53754 Sankt Augustin, Germany
Email: erion@elmasllari.com

Amro Al-Akkad
IoT Partner & License Business
Bosch Software Innovations GmbH
10785 Berlin, Germany
Email: amro.al-akkad@bosch-si.com

***Abstract*—This paper presents findings from a qualitative study on people's attitudes, needs, and expectations towards smart energy systems. Based on interviews with individuals, both consumers of energy and those who have an energy-producing plant installed at home, energy consumption behavior is summarized and several issues are identified that impact the introduction and acceptance of smart energy and demand-management systems in households. The issues are analyzed in context and examples of user expressions are given to illustrate each. The findings can already be used as a rudimentary design space, to inform the design of smart energy systems for using and producing energy in domestic environments.**

***Index Terms*—Smart grids, Technology social factors, Power system economics, Automatic generation control, Ubiquitous computing.**

I. Introduction

The advent of distributed power production technologies, such as photovoltaic cells and windmill plants, gave rise to "energy prosumers" – people or entities that at the same time produce and consume electrical energy. The prosumers' energy demand and generation characteristics are, however, volatile and can disrupt the electricity grid. To both predict and thwart the impacts of prosumer volatility, research has focused on smart technologies, but this has only highlighted that a) technology changes are part of a larger ecosystem, which includes users b) they require a seamless interconnection between private households and Distribution System Operators (DSOs) at the technical level, and, most importantly, c) DSO business models need to change so as to present a desirable business case to the prosumers [1].

With regard to presenting desirable business cases, it has already been reported that smart energy systems can save energy in private households and office environments [2]–[4], but this potential for savings has not been sufficient to drive the adoption of such systems [5]. People fear that smart energy systems may harm their privacy, or they have concerns regarding the systems' practicality and impact on people's daily lives. Given the growing number of smart meter installations [6], photovoltaic cells [7], wind turbines [8], and other power plants that increase the grids' volatility, overcoming the prosumers' skeptic stance has become a pressing issue for the deployment and acceptance of smart energy systems. To solve this issue, a thorough understanding and analysis of user needs and motivations is necessary.

Based on research with actual users, this paper opens the discussion and presents initial findings on people's habits, needs, expectations, and concerns related to smart energy systems. We studied how people's living space is arranged from an energy usage point of view, what influences their energy-related decisions, how they came to their current stance on energy usage, their preferences, their current annoyances, and as many other aspects as possible. This paper's aim is thus to guide system designers so that the users' needs and motivations can be understood and taken into account in the design of future smart energy systems.

The paper is structured as follows: we first explain the methodological approach and analyze the applicability and generalizability of these findings. Then we list user groups, common findings, and group-specific findings. Finally we draw conclusions and insights for the development of smart grid systems and business cases that users accept.

II. Methodology

The research was carried out as part of the EU FP7-funded Flex4Grid project, tasked with developing Smart Grid technologies that are accepted by prosumers and DSOs alike. The project pursues the iterative design and evaluation of flexible technologies and services for smart grids. The project consortium consists of two DSOs and an energy retailer from Slovenia and Germany, several software companies, and various research organizations from Finland, Germany, Slovakia and Slovenia. While we have studied prosumers in both Germany and Slovenia, this paper will focus only on the results from Germany. The differing price structures, price sensitivity, legal frameworks, and cultural/social traditions between the two countries do not guarantee that results from one country can be generalized to the other, even if such results are superficially similar.

The study presented in this paper is based on semi-structured, contextual interviews. As a qualitative research method, semi-structured interviews comprise both prepared and spontaneous questions, whose order is adapted to the dialog's flow. Open-ended questions are asked on purpose (e.g.

978-1- 5090-4429- 0/17/$31.00 © 2017 IEEE

"Could you please tell me about..."); these allow respondents to reflect and answer by their own words, without trying to put their answer in a rigid frame. Semi-structured interviews and open-ended questions allow the respondent to express issues of importance to him/her, even when these are unexpected from the researcher. The results from semi-structured interviews enable understanding of complex user contexts [9] and at the same time point towards concrete user issues that can later be corroborated by quantitative methods.

In total 12 participants were interviewed, as described in the section on "Findings". Wherever possible we carried the interviews out in the participant's home and also had a "guided tour" of the house and the devices in use. This makes it easier for participants to remember details or experiences that might otherwise have been forgotten. Participants who had a renewable energy plant installed were also asked to show us the systems and interfaces they used to control it. Whenever participants could not receive us at their home, the interviews were carried out at their office or favorite caffe, so as to keep the conversation neutral and not influence their stress level, as would be the case in an unfamiliar environment or research facility.

The interviews were structured as an informal talk with both moderators at the same time, whereby one of the moderators was taking notes while the other was engaged in dialogue with the user, and vice versa. An interview usually lasted 45-60 minutes. The first part consisted of introductions (research project, moderators, user) and data confidentiality assurance. Throughout the interview we emphasized both the confidentiality and the need for honest answers, and gave the participant the option to refuse to answer or to interrupt the interview at any time[1]. The second part of the interview targeted the use of energy in their daily life, habits and factors that influence their decisions, and the touch points between consumption, behavior, and payment. In the third part we covered people's understanding of smart meters, smart energy systems, and the expectations and concerns about installing such systems in the household. Prosumers were also asked about the reasons behind acquiring a power plant and about their behavior and experiences before, during, and after installation of the plant.

In order to not influence participants and to find out their true perceptions, we did not give an explicit definition of "smart energy systems" in advance. A later analysis of the statements revealed that our participants understand "smart energy systems" to mean "systems that can measure and report energy usage from household devices, and that can control these devices".

Recruitment of participants and generalizability of results

As is common in research projects, only a limited budget was available to recruit prosumers [10]. Additionally, the consortium members were forbidden by law to offer cash or cash-equivalent rewards to participants. This restricted users who accepted to take part in our study to only two kinds:

1) Employees of the DSOs and their relatives. Due to their position, these users receive a more convenient price from the DSO compared to the general population. This translates to less price-sensitivity and more comfort-seeking behavior in relation to energy use. The majority of these users did not own their homes and did not own an energy-producing plant.
2) Clients of the DSOs, who are highly conscious of energy efficiency and have optimized their households to the point of even winning prizes for their efficiency. These users pay the same price as the general population, but their energy awareness comes from their beliefs rather than from sensitivity to the price. These users were more likely to own their homes and have installed energy-producing plants.

As is obvious from the descriptions above, this sample is not random, nor does it seem statistically representative of the wider population. We believe that the study of this sample was nevertheless valuable and that the results are valid for the wider population, for the following reasons:

- The study is not quantitative, but qualitative. Its aim is to uncover how to best approach users of smart grid systems. Since the participants are potential users of smart grid systems, the findings represent valid points from which to start a deeper, quantitative enquiry.
- The two kinds of users represent opposed extremes in several dimensions: energy awareness, contract price, consumer vs. producer status, renting vs. owning their homes, and comfort-seeking vs. awareness-motivated behavior. Despite these differences, both kinds of users raised very similar issues and had very similar expectations, as reported further in this paper. This is a strong indicator that the issues do not depend on group characteristics, but are instead common across the underlying population. Future, quantitative work should shed light on the extent to which this is the case.

III. Findings

Two user groups were identified as a result of the interviews. They are similar in most aspects, but certain behaviors, habits, and needs occur only in one group or the other. In the sections below we first describe the user groups, then the findings common to both, and finally the few findings that are specific to each group.

A. User Groups

- The defining characteristic of the first user group – consumers – is that these users do not own a power-producing plant. Six users in total were part of this group; ages ranged from 35 to over 60. Five consumers were working, two of them in self-owned businesses; the sixth consumer was retired. All of these users lived in 2-4 person households, usually in small towns and rented houses. Their energy contract foresees fixed prices per kWh, independent of the time of day.

[1]None of the participants took advantage of this right.

- The second user group consists of people who have installed a power producing plant and therefore both consume energy and produce it – prosumers. These users lived in a larger city (compared to consumers) or in its suburbs. They typically own their houses; ages ranged from 30 to 50 and family sizes from 3-5. All six prosumers were working (one was in temporary parental leave at the time of the interview). Prosumers have fixed prices per kWh, both for the power they consume from the DSO, and for the power they produce and sell to the DSO. Due to the legal framework, the DSO must buy from these prosumers any power they produce and can't use themselves. This was intended as a subsidy towards green power, but the buying prices have meanwhile fallen by 300%.

Since the chosen research method requires only four to five users per group [11], the results for each group are valid and representative for the purposes of this research.

B. Findings common to both user groups

1) Habits related to energy consumption: All users were generally aware of the need to save energy, no matter whether they had preferential prices or not. As examples of their saving behavior they named: setting their fridge's temperature a bit higher; using switchable extension cords with multiple plugs to switch off a group of related devices at once; using timed switches for at least one device (typically lighting); using timed switches to set heaters at the lowest-setting over night. Households with flow-type water heaters use them sparingly.

Washing machines, fridges, freezers, driers, and water boilers were perceived as energy guzzlers, even when they had the highest efficiency class. Behavior was explicitly changed to minimize energy-usage from these appliances. In comparison, devices with a standby mode such as TVs, CD/DVD/Blu-ray players, PCs, coffee machines, and radios were not perceived as guzzlers, no matter what their efficiency class was. When told about the typical consumption of such devices, most users were surprised.

Energy efficiency was not considered a good enough reason to replace a functioning appliance. Generally, users only replaced an appliance when it broke down *and* the repair costs would be too high compared to buying a new one. The efficiency of the replacement is believed *bona fide* from the energy class on the label. Users do not verify whether the new acquisition results in actual savings, do not measure the actual consumption, and do not know how the user's own usage habits may cause actual consumption to be much higher than the given energy class.

Energy consumption during the day is relatively low, as users are at work and children at school. A peak occurs at breakfast due to power-hungry coffee machines, but other than that breakfast is cold. Evenings and weekends are associated with increased energy usage from cooking and staying in[2]. Though washing is recognized as an energy-hungry activity, users report washing when they need to, without considering network load or other factors. This was especially true for families with children.

2) Habits related to payments of energy used: Both consumers and prosumers prefer long-term contracts with a fixed price and monthly pre-payments, so that they can estimate their expenses. Being able to estimate and forecast expenses was explicitly identified as more important than paying a cheaper, but fluctuating price. All respondents see their energy consumption at most once a year, when they get the bill. If the energy costs are included in the monthly rent payments, people never become aware of their actual consumption, as the bill is not detailed enough. Users did not undertake any effort to regularly observe their consumption from the power meter. Having the meter in the cellar helps perpetuate the ignorance of consumed energy: it is, comparatively, too much effort to go to the cellar just to see the consumption. When asked about using an app to see consumption data, users said they would rather appreciate looking at the meter itself, as they expected the interaction style with an app to be a major nuisance. Users who had actually tried such apps reported that they indeed were cumbersome and annoying to interact with.

3) Attitude and expectations towards smart energy systems: Both consumers and prosumers expect a financial benefit from using smart energy systems. Moral goals, such as saving the environment, do nudge users towards smarter systems, but moral goals alone are not seen as sufficient. The need for financial benefits has also been reported independently by [1], wherefore we deem this as a confirmed finding for the whole population. The amount of benefits expected was expressed in different ways by different respondents[3], but when calculated back to a cash value, the expectations are remarkably similar: People expect an average savings or cash benefit of at least 50-100 EUR/year in order to participate in a smart energy system. Furthermore, people would not like to pay for the installation of the smart meter or system itself. This is the opposite of what various DSOs require and represents a hurdle to adoption of such systems.

Current "smart" systems are considered by users as not user-friendly enough, whereas they should be easy to use by nontechnical persons. Any necessary connections are expected to be reliable: connectivity problems should be no more frequent than those of the internet provider (1-2 times a year). Users are willing to spend at most 30 minutes once a year to configure, update, or diagnose a smart energy system; raising this time to one hour would annoy them. Users also want interoperable, open-protocol systems that can work with

[2]One of the users, who owned a business, worked from home, resulting in a different consumption spread during the day. This is not generalizable to the wider population, although the number of self-employed working from home needs to be considered when drawing up peak-pricing plans.

[3]"The system should pay off after 7-8 years", "The system should save at least 10% of yearly energy", "The system should save me at least 50-100 EUR/year compared to my current bill".

all their devices[4]. If the DSOs want to install a closed or proprietary system, users expect the DSO not only to pay for the system, but also to pay the users for the effort of dealing with it.

When asked about what a "smart" system should do, and whether the system should control home appliances for optimal energy usage, both consumers and prosumers reported the following:

- The system should help them identify "energy guzzlers".
- The system should be completely "hidden" from attention, and its optimization functions should not affect the ambience of a home.
- The system should provide information on its actions, so that users can override or plan their life around them (*"I need to know when an appliance goes on and off so I can plan my life."*). However, the system should not cause a message storm: (*"If [it lowers] my fridge temperature and I don't notice it, then why would I want an email that tells me [it was done]?"*).
- When people are at home, they will give the smart system control only if it does not cause noticeable effects, i.e. when the system's control of an appliance will not conflict with the user's usage of it, or with the user's expectations about the appliance's behavior. An often cited example was: *"If the remote control changes my fridge so that my food spoils sooner, then I will notice and will not like it"*.
- People want to permit or reject the system's control for each appliance separately, e.g. "allow the system to control my fridge downstairs but not the coffee machine in my kitchen"; if that is not possible, the granularity of permissions should be at least per type of appliance ("Control my fridges, but not my TVs"). For every device there should be a possibility to override the system's optimizations: *"I want this appliance to start now, I don't care about price or DSO network planning."*.
- The smart energy system should trigger appliances to operate based on certain events, not based on time (*"Start the dishwasher when it is full, not necessarily at 7am every day."*). Another acceptable triggering method is "deadline-based triggering". Both consumers and prosumers mentally organize their household tasks by "end time", not by "start time"[5]. They expect the system to accept a deadline by which a process should be finished, then optimize energy and control so that the deadline will be respected. Paraphrasing a user, *"[If I say clean the clothes by 9pm, then the system can do whatever it wants between now and 9pm, as long as it is finished by 9pm.]"*.

Users understand "remote control of appliances from the DSO" to be equivalent to "remote access from the DSO to the home network". They report the same preferences and needs mentioned above, but require in addition that the system be secure and that the user have ultimate authority over each appliance's state. Users generally would trust their DSO with their consumption data, but they are afraid that remote access to a smart meter or smart system impacts the security of data on the home network. Security and network isolation was particularly important for home-office workers who deal with confidential data from clients (insurance agents, realtors, etc.).

The preferred means of communication between user and system when the user is away from home were reported to be Email, SMS, WhatsApp, or similar everyday communication channels. Ease of access to the smart meter and the measured data is paramount; users prefer to have the smart meter accessible at home, not in the cellar. Those users who had experience with smart meter monitoring apps reported that their interest in consumption details lasted only for the first two weeks and they never opened the app afterwards. This behavior was independently confirmed by the DSOs we worked with, wherefore we deem this as a confirmed finding for the whole population. Instead of using an app to see a consumption report, users prefer an app that notifies them when some consumption value is significantly out of normal range: *"I don't want a message every day that tells me everything is normal"*.

4) Perceptions related to developments in the energy domain: Most users cannot explain the notion and function of a smart meter, even though current legislation makes such meters mandatory. Most users do not know that smart meters send out data; they think the smart meter only shows the momentary consumption. The privacy implications of smart meters are unclear to the users. When told about behavior monitoring possibilities that a smart meter opens, users report that they do not object to the DSO knowing their habits, but they would not accept smart-meter and habit data to be given to third parties: *"My data can be used [by the DSO] for network management, but not to give me offers or by third parties. I also need to know for what my data was used for. The initiative for giving data to third parties should come from me and the data should be deleted after the report is complete."*

As a proposed energy storage mechanism, electric cars are considered inappropriate by both groups. They are seen as not affordable, lacking charging infrastructure, and impractical: *"Charging with a 2000 Euro recharging station requires one whole night!"*. Users point to new demand peaks: *"Everyone coming home at same time will put the car to charge – unless they can charge it elsewhere."* Photovoltaic-energy prosumers in particular do not believe e-cars can help them: *"It never works in real life: when you are home in the evening there is no sun, and when there is sun you are at work."*. It was also pointed out that, to charge the e-car at work, one would have to pay the employer for the energy used; this would negate the benefit of having a photovoltaic plant at home.

[4]A quote: *"[We already have entertainment systems that do not work with each other]. If we can't manage to make things work together in a single house, how can we think we can do it for a wider area?"*.

[5]A typical example was: *"I set the washing machine to start at such a time that it will be finished by 7 am when I go to work. On my way to work I pass by the cellar, take the clothes out and put them in the dryer so they will be ready by the time I come back from work. When I come back, I pass by the cellar, get the dried clothes, and bring them home on my way upstairs"*

C. Findings particular to one group only

1) Habits related to energy consumption: When *consumers* buy new appliances, energy efficiency is a consideration, but only together with looks, build quality, and price. These latter three characteristics may push the decision towards a less-efficient, second-hand appliance, especially for washing machines, dishwashers, and similar. The functionality of an appliance is often considered to be more important than its energy efficiency. For *prosumers*, the energy class of a new appliance was a serious consideration; their tendency was rather to upgrade the devices with the most energy-efficient version they could afford. While the prosumers' appliances sometimes had some "planning" functionality compared to the consumers' (e.g. washing machines had a start-delay timer), this functionality was used only by one prosumer.

Having an own power plant makes *prosumers* more likely to shift their habits so as to use their own power, e.g. by setting up alerts to inform them when enough self-produced energy is available and then starting appliances at that time.

2) Habits related to payments of energy used: We reported earlier that both user groups preferred fixed-price contracts and pre-pay monthly for the expected consumption, with the actual consumption bill coming at the end of the year. *Consumers* prefer local energy providers because "*they are easier to reach in case of problems*". The consumers estimate their own "energy-saving behavior" by checking whether the sum of their monthly pre-payments is enough to cover the billed amount. We draw attention to the fact that they do not compare the kWh numbers to the previous year, but only check whether they need to pay more, or whether they get some money back from the DSO. Not having to pay a difference was psychologically equivalent to having saved energy. This level of indirection is arbitrary and already makes it impossible to judge one's own consumption, but several consumers had gone one step further and had explicitly asked the DSO to collect higher monthly pre-payments. This way, at the end of the year they would be certain to get money back: *"I pay more than necessary every month, just so that at the end of the year I don't have to pay a difference."*. These consumers were fully aware that this way of estimation could result in using more energy, but would take that risk in exchange for "peace of mind and predictability".

Prosumers also choose the local providers, but they do so in order to support the local economy. They also agree that receiving money back is a good feeling, but argue that paying a difference at the end of the year is financially better, as it allows them to profitably invest the amount that would otherwise be overpaid to the energy retailer.

3) Attitude towards smart energy systems: As most *consumers* lived in rented houses, it was either not worth or not allowed for them to install a power production plant. The few who owned a house thought that a self-paying production plant of at least 40-50 square meters was larger than their space allows. They universally agreed that, if building a new house, they would install a PV system, but only if governmental subsidies were available. The market price from selling excess production was too low to be interesting for them.

Remote control of their appliances by the DSO (or automated control by a smart system) was perceived by consumers as a kind of promise or contract: *"I, the user, will postpone washing dishes until you, the DSO, say it is OK"*. This raises the fear of needing to change habits and behavior. *Prosumers* seemed less affected by this fear – perhaps because they have already modified their behavior to match sunlight hours. *Consumers*, instead, emphasized their need for full flexibility and/or not to be bound by the perceived promise: *"I use devices when I have time. The system does not know when I have time."*.

Consumers would accept that smart systems control household appliances when nobody is at home. This last point, however, was contested by *prosumers*: Due to insurance, legal, or contractual obligations, prosumers did not want an automated system to turn appliances on and off when nobody was present. A typical example was that, if a washing machine causes water damage while nobody is at home, the insurance would explicitly deny compensation.

With regard to the events triggering the start or stop of an appliance, *prosumers* have special needs: the availability of energy from the own power plant should be taken into account: *"I'd like to have a system, that when the sun goes up, turns on this and that, so I can use my own energy."*.

While privacy was deemed important by both groups, prosumers were more sensitive to privacy-related issues and more opposing of data-sharing with third parties: *"Intelligence should be here with me; I want to download the apps and they do stuff with my data here in my home, not to send my data away."*

IV. Conclusions and future work

The presented work contributes to the stream of research that applies a user-centered design approach to tackle the challenges of deploying smart grid projects [12], [13]. Our findings are a valuable initial step to inform the design of smart energy systems in general, and the system being developed within the Flex4Grid project in particular. The following issues were identified and need to be correctly solved if smart grid systems are to be accepted and deployed by end users:

- Users expect a cash-equivalent benefit from using smart grid systems. DSOs should take this into account when drawing up business or marketing plans.
- Users do not welcome the cost of installing a smart meter. DSOs should find ways to finance the installation, or motivate users to do so.
- ON/OFF control, which is the only one possible with the current generation of non-smart appliances, is not enough to achieve conflict-free, problem-free control of the appliance by a smart grid system[6]. Smart Grid projects should either take into account the time it takes for the appliances

[6]As an example, the washing machine settings would be lost if the machine is turned off by the system; the user would need to re-input the settings again.

to break down and be replaced, or should find ways to incentivize upgrading to ”smarter” appliances.

- Automated control of appliances conflicts with applicable legal, contractual, and insurance frameworks. Legal models must be found or created that exclude users from responsibility for actions taken by a smart system.
- Clear privacy and data protection rules must be presented whenever introducing smart grid systems.
- The usability of system interfaces needs to be carefully engineered to a) assure acceptance from non-technical users and b) not require particular configuration and maintenance.

This paper’s conclusions will be extended and further corroborated in future work. In particular, user research will be carried out with users who neither produce their own energy, nor have convenient pricing contracts. Understanding the needs and motivations of such users and their susceptibility to various motivators will greatly improve our understanding of the acceptance of smart energy systems. Further interviews will also be carried out with more participants from each group, so as to associate each need and motivation with a concrete statistical significance. Ultimately, this will help to organize our findings according to their priorities, in a ”design space” that helps system designers quickly identify acceptable approaches for smart grid systems development.

Acknowledgment

This research was carried out under the EU Horizon 2020 project Flex4Grid, Grant agreement nr. 646428.

References

[1] S3C Project, *S3C Deliverable 3.4*. S3C Project, 2014. [Online]. Available: http : / / www . s3c - project . eu / Deliverables.html.

[2] M. Jahn, T. Schwartz, J. Simon, and M. Jentsch, “Energypulse: Tracking sustainable behavior in office environments,” in *Proceedings of the 2nd International Conference on Energy-Efficient Computing and Networking*, ACM, 2011, pp. 87–96.

[3] J. Schleich, M. Klobasa, M. Brunner, S. Gölz, and K. Götz, “Smart metering in germany and austria: Results of providing feedback information in a field trial,” Working paper sustainability and innovation, Tech. Rep., 2011.

[4] T. Schwartz, S. Denef, G. Stevens, L. Ramirez, and V. Wulf, “Cultivating energy literacy: Results from a longitudinal living lab study of a home energy management system,” in *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, ACM, 2013, pp. 1193–1202.

[5] F. Gangale, A. Mengolini, and I. Onyeji, “Consumer engagement: An insight from smart grid projects in europe,” *Energy Policy*, vol. 60, pp. 621–628, 2013.

[6] T. Ryberg, “Smart metering in europe,” in *M2M Research Series*, Berg Insight, 2014.

[7] A. Sharma and W. Shafer, “Top solar power industry trends for 2015,” *Rep. Np: IHS Technology, nd Print*, 2015.

[8] L. Fried, S. Shukla, S. Sawyer, and S. Teske, “Global wind energy outlook 2014,” *GWEC., Belgium*, 2014.

[9] L. E. Wood, “Semi-structured interviewing for user-centered design,” *Interactions*, vol. 4, no. 2, pp. 48–61, 1997.

[10] G. Lindgaard, “The usefulness of traditional usability evaluation methods,” *Interactions*, vol. 21, no. 6, pp. 80–82, 2014.

[11] J. Nielsen, *Why you only need to test with 5 users*, 2000.

[12] J. Glatz-Reichenbach, C. Lindkvist, T. Vilarinho, A. Minde, G. Cretella, and L. W. Wienhofen, “End user centred interactive software architecture and design: The creation of communities for a smart energy use,” in *Innovations for Community Services (I4CS), 2015 15th International Conference on*, IEEE, 2015, pp. 1–8.

[13] L. W. Wienhofen, C. Lindkvist, and M. Noebels, “User-centered design for smart solar-powered micro-grid communities,” in *Innovations for Community Services (I4CS), 2014 14th International Conference on*, IEEE, 2014, pp. 39–46.