GUIDELINE: TESTING TARIFF SCHEMES IN A PILOT CONTEXT

Abstract

This guideline targets parties involved in smart grid research projects, which aim to test innovative tariff schemes. The guideline gives practical advice to researchers on how to test a tariff scheme in an experimental set-up. It also provides suggestions to face barriers of different nature (e.g. regulatory) which might hamper a realistic application of the tariff scheme. For optimal use of this guideline, the reader must be familiar with dynamic tariffs.

What is it?

This guideline gives practical advice on how to implement a tariff structure in a pilot context. Its objective is to provide guidance for implementing and testing a tariff scheme in an experimental set-up, i.e. pilot or field trial. This implies that the consumers will not actually be billed according to the tariff. The guideline does not discuss the process to design the tariff. For information on how to design a tariff scheme see the S3C guideline Designing a dynamic tariff.

The structure of the guideline is as follows: the section “When to use?” provides a characterization of the recommended context to implement the guideline. In section “What do you need to do?,” financial and organizational factors for setting up a tariff structure in a pilot are discussed, along with certain considerations for these factors. To illustrate these factors, a summary of the main findings of the Linear project are presented and compared to the identified factors. The section “Do’s and don´ts” provides practical recommendations when implementing such tariffs structures.

When to use?

Ideally, innovative tariff schemes ought to be tested in a setting which is as close to reality as possible. That is to say, the field trial must mimic as close as possible real life conditions. Innovative tariffs are tested in a mock set-up (e.g. pilot) because such a setting facilitates their introduction and implementation. This type of settings are useful to circumvent regulatory requirements that may exist across European countries (and which currently do not allow the implementation of such dynamic tariffs). These regulatory requirements may represent barriers for the testing of such tariffs. An example of such requirements is billing consumers according to standard load profiles, the latter which are based on historical data. As such, they do not reflect the ongoing behaviour of the end-consumer. Thus, these profiles are less appropriate for grasping ongoing changes that alter the electricity consumption of households (e.g. heat pumps, PV panels, electric vehicles).

The considerations given by this guideline should be kept in mind when testing a tariff scheme to ensure realistic testing results. This will enhance their usability for parties involved in smart grid pilot projects aiming at testing tariff structures. As the application of this guideline is limited to field trials/pilots, it does not address utilities wishing to apply a certain tariff in real-life. Furthermore, due to its practical approach the guideline does not give a complete overview on the theory of conducting experiments, but rather lists some practical tips and potential pitfalls.

What do you need to do?

To implement a tariff structure in a field trial some factors should be considered. These factors may be grouped into financial and organizational factors. These factors are listed below (organized by group):

- Financial factors
  - Influence of current energy contract.
  - Revenue neutrality.
  - Avoiding financial risks for participants.
  - Rates should reflect system costs while giving a proper incentive.
  - Monetary and non-monetary incentives.
- Organizational factors
  - Reference profile.
  - Duration of the field trial.
  - Number of participants in the pilot.
  - Variation in tested schemes.

Depending on the specific objective(s) of the project, some factors might be less or more important. That is, relevancy might change with the scope of the pilot. Moreover, it must be noted that the budget and timing of the project might limit the considerations given to some of these aspects.

Financial factors

Influence of current energy contract

In principle, the ideal situation would be to bill participants according to the tariff structure(s) tested during the trial(s). This will ensure that their behaviour is not influenced by their own energy contract.[1] Unfortunately, this is often not the case. Additionally, it may be difficult to achieve such an ideal situation due to regulatory stipulations. Most of the time, consumers subscribe two contracts: (1) a supply contract with a retailer and (2) a contract proposing innovative tariff structure(s) to be tested within the pilot. Both contracts coexist within the project. For undistorted

[1] Contract subscribed with a supplier for the delivery of the electricity service.

results to be obtained, participants should only consider the tariff proposed in the field trial. In reality, however, participants are often billed according to the tariff subscribed with its retailer. This diminishes the signals to adapt behaviour provided by the innovative tariff scheme.

It is often seen that participants sign the second contract with the utility involved in the pilot. As the contract signed with the retailer, this contract ensures privacy and data security. Additionally, it can contain extra agreements concerning incentives (e.g. bonus-malus payments). Incentives may be given to consumers based on how they react to the signals provided by the tariff scheme.

To illustrate the situation described above, picture an consumer acting according to a dynamic tariff (pilot tariff scheme), while his own electricity contract has a day and night tariff (contract subscribed with the retailer). This situation may alter the behaviour of the consumer in such a way that she shifts some of her electricity consumption from valley to peak periods. The end result would be a higher retailer invoice.

A survey issued during the recruitment phase of the project can support the effectiveness of the tariff scheme. The survey can shed light on the factors participants value the most (in respect to their profile) and the challenges they might be facing in handling better their energy consumption. For more information on how to create a better picture of your target group see the guideline Learning about target groups.

Revenue neutrality

Each proposed tariff structure should be revenue neutral. This means that in the absence of any load shifting, the tariff should not lead to unrealistically high or low electricity costs. At individual level, some electricity costs could increase while others decrease if consumers wouldn't adapt their behaviour. However, the average consumer's electricity cost should not change. In this case, consumers change their behaviour according to the tariffs, they could save money. This is to say were the consumers actually billed according to the tariff.

Avoid financial risks for the test users

The proposed tariff structure should not be a burden to consumers in this pilot project. That is, it should not create extra costs for them. Although (monetary) incentives can be offered to those that showed the desired behaviour, those that did not improve on their energy consumption behaviour or even worsened it should never be financially impacted by this during the pilot. This can be realized by different means. In order to win the consumers' trust and to facilitate the recruitment process, a risk management clause can be included in the participation contract for

the households taking part on the field test. This will ensure that participants will not face extra costs.

Rates should reflect system costs while giving a proper incentive

The information on current electricity prices provided by the implemented tariff scheme has to give an incentive to the consumer to shift their consumption. Consumers should thus be able to obtain a financial gain or perceive other benefits when adapting their electricity consumption.

While a significant price signal or other clear incentives are important, the rate should in effect reflect the cost of providing power to the customer. In other words, the tariffs should be realistic given the context of the smart grid project (which might also be a future scenario). Similar to the requisite for revenue neutrality, unrealistically high or low prices would lead to unrealistic results. For instance, if prices are unrealistically high, there is a risk that consumers do better during the field trial than they would in reality as they have more incentive to reduce consumption during times of high prices.

In a scenario where the main factor to be investigated is the price elasticity of the end-consumer, i.e. to find out a threshold for actions not based on actual economic conditions, the price spread to be introduced does not have to adhere to the given energy economy realities. Such research can offer valuable insight into the economic realities of consumers.

Monetary and non-monetary incentives

A variety of monetary and non-monetary incentives can be considered by project and tariff designers to create an incentive scheme supporting the tariff(s) they would like to test in their field trial. To use monetary and non-monetary incentives is not an either-or-question. Designers may use a multitude of combinations that can be changed over time (within the duration of the project). Using these incentives help to overcome phases in which customers lose interest. For instance, interest from consumers may be regained through gamification and/or the introduction of competition. For more information on incentives see S3C guideline on incentives, Choosing and combining monetary and non-monetary incentives.

Note that the selection of incentives should be done with care. This is related to the prerequisite for the tariff to reflect system costs while giving a proper incentive. Incentives can be added to support pricing schemes, but if incentives given are not realistic (i.e. cannot be implemented in a real-life setting) they can impact the results of the trial. In general, incentives provided to participants should be selected so that they do not influence electricity consumption behaviour. Incentives should allow for the change in energy behaviour to originate mainly from the tariff scheme being

tested. To reduce as much as possible the distortion of results, incentives should be unrelated to the level or timing of consumption or, in effect, tied to the amount of bill savings according to their actions (Faruqui et al, 2009). Moreover, giving incentives towards the end of the pilot might incentivise participants to maintain their best efforts.

A simple tariff arrangement may be coupled with new services and products. In a smart ICT-based energy system, not only kWh (energy) can be sold to the consumer. For instance, energy related services, e.g. smartphone apps, can increase the consumer's level of understanding of their new tariff arrangement. This in turn increases the awareness of participants on actions they can take. In addition, new services may offer extra incentives beyond the tariff. In this case, incentives directly related to the tariffs and the extra incentives stemming from new services and products can be differentiated and measured.

Renewable pricing (Linear, BE)

Within the Linear project, a tariff is developed based on day-ahead Belpex prices adapted for the situation in 2020. Since more renewables are expected in 2020, day-ahead wind and solar predictions are translated into prices via resiliency analysis[2]. The tariff has 6 fixed time blocks. The rates in these time blocks, however, change daily, based on day-ahead Belpex prices and wind and solar predictions.

The tariff is chosen so that the energy cost for an average consumer is *cost-neutral*. This is realised by applying a rescaling factor. This neutrality has the effect that if the average consumer does not adjust their consumption behaviour, the Linear invoice would equal the invoice of the retailer invoice. If the consumer adjusts their consumption behaviour, however, they can gain money by moving consumption from expensive to cheap price periods.

Pre-trial measurements are used as a *reference*, i.e. the difference between the consumption pattern of the base year and the year of the actual intervention. For the reference period typical days are developed (e.g. consumption pattern on a typical weekday in august). These typical days will be compared to the actual consumption during the field test to determine the shifted consumption and realized savings.

The *compensation* of the Linear customer consists of:

- A basic fee of 100 € which gives consumers an incentive to participate in the project, but also lowers the risk to participate.
- A variable fee determined as the difference between the reference invoice and the field trial invoice. If the reference invoice is higher, the variable fee is added to the basic fee. In contrast, if the reference invoice is lower, the variable fee is deducted from the basic fee with the limitation that the compensation can never go below zero.
- Moreover, to avoid extra costs for participants that shifted consumption from night to day (having a day and night tariff), the Linear-project compensated the costs caused by this

[2] This analysis states the wholesale price sensitivity due to an increase in offer or demand on the market.

change in behaviour (based on their past behaviour). This “risk-free” measure was implemented to encourage consumers to provide flexibility to the trial. However, a large number of participants still focus on the conditions of their energy contract. Survey results also revealed that some participants, from the Linear time-of-use tariff group, were not focussing on the Linear-tariff, nor on the night and day tariff, but were adapting their consumption to the production of their PV installation.

The final compensation is given at the end of the project. Table 1 summarizes the main findings compared to the identified factors. More information on how these factors were considered within the Linear project see (Dupont et al, 2011 and 2012).

Factors	Consideration
Influence of current contract	Compensation for influence current day/night tariff, but side-effects are still possible
Reference profile	Pre-field trial measurements
Duration of field trial	1 year of reference measurements + 1 year of trial
Number of participants	55 families react manually to the tariff scheme 185 families have automated control of smart appliances according the tariff scheme (but during limited time periods)
Revenue neutrality	OK for average participant
Financial risk	Compensation for shifting consumption form night to day and compensation can never go below zero.
Rates should reflect system costs	2020 scenario + 6 price levels based on renewables + market prices
Proper incentive	Doubtful, compensation can never go below zero
monetary and non-monetary incentives	Basic fee unrelated to consumption + paid at end of the project
Variation of schemes	Only one tariff structure / manual + automated control

Table 1 Factors to be considered when implementing a tariff structure in a pilot

Organizational factors

Reference profile

In order to determine the impact of the tariff structure, the shifted consumption and the accompanying savings should be measured. Hence, somehow you need to estimate what the consumers would have done when the tariff structure was not applied - in other words, you should come up with a reference profile. There are different options:

- According to (Faruqui et al, 2009), this should be done by including a control group, which is similar in all other respects to the consumers subject to the tariff structure(s) (the target group). Once both groups are defined, load profiles should be logged/recorded. This method only holds if the two groups are representative.
- If a control group is not used, another option could be to compare the field trial results with reference profiles of the target group (before the field trial) or standard load profiles, more about this can be found in the guideline How to create a consumption baseline. If this option is used, however,

note that many factors can influence the results. Some of these factors may be:
    - The weather
    - Change in household composition (e.g. birth of a child)
    - Change in life pattern (e.g. a person going into retirement)
    - Change in equipment/loads (e.g. smart appliances given as an incentive within the project)
    - The economy (e.g. energy crisis).
- A third option would be the combination of the two previous ones. That is, having a control group and the pre-measurements of the target group. This will allow to assess whether the control group was chosen well.

Moreover, in order to interpret the results in the correct way, data should be collected not only on customer load profiles but also on socio-demographic characteristics and attitudes toward energy use (Faruqui et al, 2009).

Duration of the field trial

The time frame should be large enough to obtain representative results and to include seasonal effects. The duration of the trial should be suitable to test fatigue effects on participants. To test for these effects, it is recommended that testing subjects are encouraged to stay in the pilot for as long as possible.

Number of participants in the pilot

A sufficient numbers of testing subjects should be recruited. According to (Faruqui et al, 2009), it is recommended that at least 100 participants constitute the sample. This is for both the control and target group. If the number of consumers that participate is not sufficient, results cannot be interpreted with statistical significance.

If qualitative learning is the aim, e.g. learning on how customers interact with new smart grid technology in their homes and premises, test samples with less than 100 consumers may be sufficient. Qualitative data can be obtained by way of surveys, cultural probes, direct interaction, etc. Qualitative data obtained via such approaches offers valuable insights on the acceptance of smart grids technologies and related products. For instance, tariffs and incentives that can motivate consumers to take actions. Additionally, such data may shed light on obstacles that prevent them from doing so.

The decision on the number of participants thus strongly depends on the project's design (e.g. learning objectives) and budget (money and time).

Variation in tested schemes

If the budget (financial and time-wise) allows it, variations of the tariff scheme may be tested within the trial. Some examples are: testing a variety of tariff structure

designs, including high and low variations of each rate type; testing different feedback mechanisms and measuring the impact of enabling technologies.

Furthermore, customer segmentation can be implemented. This helps to choose the best tariff suited for the different segments. In case a variety of tariffs are to be tested for the same sample, it is recommended to slowly increase their complexity. Start with an easy or even flat tariff and just get feedback on consumption. Then, shift to an easy time-of-use or consumption based tariff customers can easily adapt to. The adaptation would be manual. Introduce more flexible structures that require automated energy management systems only when manual adaptation has been recorded. Flexible tariff structures may present a multitude of pricing levels whose distribution can change on a weekly or even daily basis. This progressive approach can help reduce the feeling of being overburdened with complex tariff schemes. The approach can also reduce the loss of interest in the new tariffs after a few months of being introduced.

Introducing different tariff arrangements (AlpEnergy,DE)

Within the AlpEnergy project, 170 households participated in the testing of tariff arrangements (TOU) with different levels of complexity. 100 households tested the static pricing model, which had two price levels (spread 5ct/kWh) distributed in two time zones. The remaining 70 households tested the dynamic model, which consisted on five pricing levels (maintaining the same spread between highest and lowest prices) distributed in five time blocks. Surveys throughout the field trial suggest that increasing the complexity of the tariff scheme may reduce the motivation for shifting consumption. This was supported by the fact that participants on the less complex tariff scheme shifted 2% of their consumption, while other participants shifted only 1%. Furthermore, 90% of consumers testing the static tariff scheme (which required manual adaptation of consumption behaviour) considered incentives and feedback instruments (information was provided via web portal) as adequate.

Table 2 highlights organizational factors taken into account for the field trial.

Factors	Consideration
Reference profile	Pre-field trial measurements
Duration of the field trial	1 year of reference measurements + 1 year of trial
Number of participants	100 reference customers react manually to the tariff scheme (static price model) 70 reference customers have dynamic tariffs and 30 of them were equipped with a smart home set
Variation in test schemes	Two tariffs schemes: - Two price levels distributed into two price zones (static price model) - Five price levels distributed into five price zones (dynamic price model)

Table 2 Organizational factors within AlpEnergy project

For more information about the AlpEnergy project see http://www.alpenergy.net/

Do's and don´ts

- **Select monetary and non-monetary incentives that support the tariff scheme**. Incentives may be coupled with services and products.
- **Increase gradually the complexity of the tariff scheme**. To avoid confusion and reduce loss of interest for the consumer.
- **Don't create risk for consumers**. Avoid the burden of extra costs for consumers by providing a risk management clause in their participation contract.

Further reading

- A. Faruqui, R. Hledik, and S. Sergici, "Piloting the smart grid," The Electricity Journal, Volume 22, Issue 7, August–September 2009, Pages 55–69.
- B. Dupont, C. De Jonghe, K. Kessels, and R. Belmans, "Short-term Consumer Benefits of Dynamic Pricing," IEEE, International Conference on the European Energy Market, 8th edition, Zagreb, Croatia, May, 2011.
- B. Dupont, J. Tant, and R. Belmans, "Automated Residential Demand Response Based on Dynamic Pricing," IEEE, International conference on Innovative Smart Grid Technologies, 3rd edition, 2012. Berlin, October, 2012.

This guideline was developed in the S3C project, and is freely available from www.smartgrid-engagement-toolkit.eu.

S3C paves the way for successful long-term consumer engagement, by acknowledging that the "one" smart consumer does not exist and uniform solutions are not applicable when human nature is involved. Beyond acting as a passive consumer of energy, consumers can take on different positions with respective responsibilities and opportunities. In order to promote cooperation between consumers and the energy utility of the future, S3C addresses the consumer on three roles. The *smart consumer* is mostly interested in lowering his/her energy bill, having stable or predictable energy bills over time and keeping comfort levels of energy services on an equal level. The *smart customer* takes up a more active role in future smart grid functioning, e.g. by becoming a producer of energy or a provider of energy services. The *smart citizen* values the development of smart grids as an opportunity to realise "we-centred" needs or motivations, e.g. affiliation, self-acceptance or community.

S3C performed an extensive literature review and in-depth case study research in Smart Grid trials, resulting in the identification of best practices, success factors and pitfalls for consumer engagement in smart energy ventures. The analysis of collected data and experiences led to the development of a new, optimised set of tools and guidelines to be used for the successful engagement of either Smart Consumers, Smart Customers or Smart Citizens. The S3C guidelines and tools aim to provide support to utilities in the design of an engagement strategy for both household consumers and SMEs. The collection of guidelines and tools describe the various aspects that should be taken into account when engaging with consumers, customers and citizens. More information about S3C, as well as all project deliverables, can be found at www.s3c-project.eu.