GUIDELINE: DESIGNING A DYNAMIC TARIFF

Abstract

Dynamic pricing schemes aim to motivate consumers to shift and/or decrease their energy use. This guideline gives some insights on the design aspects of these pricing schemes and some key lessons based on current experiences. Moreover, an overview is given of the different tariff types which are being tested today. The guideline firstly targets parties involved in smart grid projects wishing to test innovative tariff schemes, but can also be used as background information for researchers or energy actors wishing to learn more about dynamic pricing.

What is it?

This guideline will give some guidance on how to design dynamic prices to stimulate behavioural change in electricity consumption and will start from the attributes that define tariff schemes. The figure below introduces the main attributes.

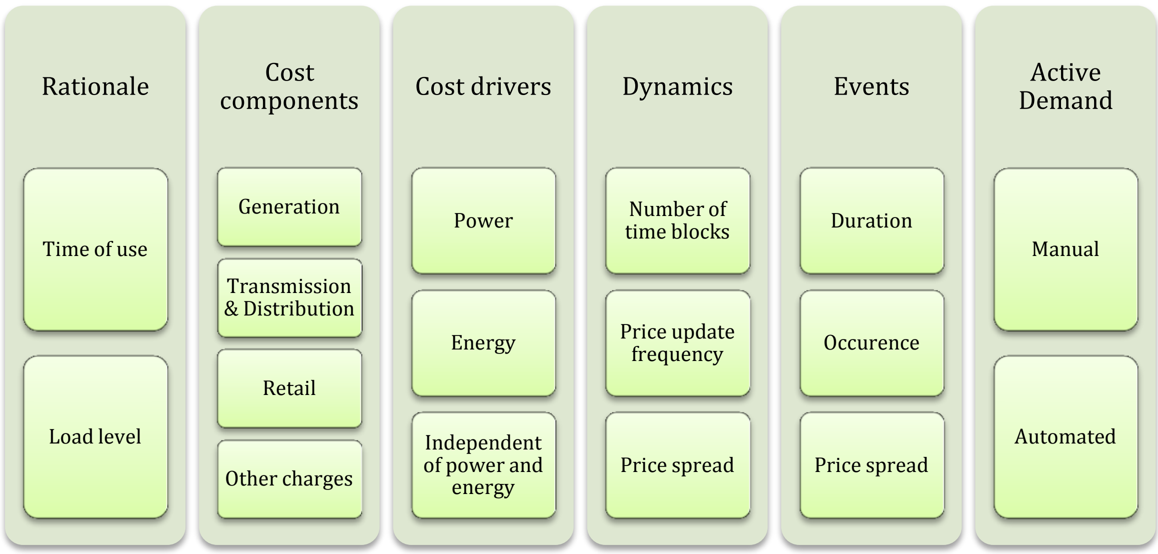

Figure 1: Overview of pricing scheme attributes.

The basic **rationale** behind dynamic pricing is that the energy price varies either by *time of use* and/or by the current *load* at household level. Different **cost components** are present in energy pricing reflecting the value chain of energy, i.e. *generation, transmission and distribution (T&D)* and *retail*. Moreover, for a given component, different **cost drivers** can be distinguished: costs driven by *energy* usage [€/kWh], by *(peak) power* [€/kW] or costs that are *independent of these factors*

[€]. An example of the latter is the metering cost which is driven by the number of customers connected. The underlying costs of the generation and T&D business largely depend on the energy usage and the (peak) power. Both the generation and the T&D components are thus candidates to be made dynamic and this can be done according to the energy usage (rate per kWh) and/or the (peak) power (rate per kW). The **dynamics** of a pricing scheme can be expressed by the *number of time blocks* per day in which the rate can vary, the *price update frequency* and the *price spread,* i.e. price differentials between time blocks. In addition to these characteristics, also **extraordinary events** can be integrated by introducing lower priced periods (rebates) or higher priced periods (price peaks). These events are defined by their *duration* (e.g. 1 hour), their *average occurrence* (e.g. 10 times a year) and the *price spread* (price differentials between events and non-events rates). Finally, end-users enrolled in price-based **Active Demand programs (AD programs)** may respond to price signals in a *manual* or *automated* way, for more information on this see our guideline Using flexibility automatically or manually.

When to use?

This guideline will explain the basic principles to take into account when designing an innovative tariff scheme. The developed tariff schemes can be tested in different smart grid projects resulting in a wider roll-out ones proven to generate the desired response from customers.

The implementation of a tariff scheme in a project should typically occur at the start of the project. The chosen tariff will be an important financial parameter to be taken into account by the project developers when determining a proper business case. In addition, if the tariff scheme is designed in an early phase of the project, there remains more time to involve end users in the design phase of the tariff in order to take their preferences into consideration. The emphasis on customer involvement in the design phase will facilitate the adoption of dynamic pricing schemes.

Depending on the design of the tariff structure, different objectives can be achieved. The project goal itself thus determines how the different attributes should be addressed. In the table below, we will give an overview of the tariff types that are mostly tested today, describing the way they fill in the attributes to reach their respective objectives.

Most tariff structures can be classified in the following subcategories: Time-Of-Use pricing (TOU), Dynamic rate or Real-Time Pricing (RTP), Critical Consumption Pricing (CCP) which includes Critical Peak Pricing (CPP) and Critical Peak Rebate (CPR), and Consumption-based tariffs

Table 1: Goal and attributes of different tariff types

	TOU	RTP	CCP		Consumption-based
			CPP	CPR	
Goal	Change routine behaviour of end-users to improve base load (e.g. to increase RES uptake)	Adapt consumption to external variables (e.g. spot prices, prognoses, excess power from RES, grid overload)	Reduce critical peak demand (e.g. in case of grid overload)	Increase demand when electricity is abundant (e.g. in case of excess power from RES)	Energy saving and a general load reduction or consolidation at a certain load level
Rationale	Time of use	Time of use	Time of use	Time of use	Load level/overall consumption
Applicable to following cost components	Generation T&D	Generation T&D	Generation T&D	Generation T&D	Generation T&D
Cost driver	Energy	Energy	Energy	Energy	Energy
Dynamics					
• **Number of time blocks /day**	Limited (3-6)	Hourly, Quarter-hourly (24, 96)			2-x tariff blocks based on share of consumption or based on overall currently used load
• **Price update frequency**	Reflect average cost of energy (weekly, monthly, seasonally,…)	Reflecting system costs (Daily)			static
Events					
• **Type**			Peak price	Rebate	
• **Duration**			Short	Short	
• **Occurance**			A few times a year	A few times a year	
Price spread[1]	Considerable (typical ratio 2-4)	Considerable (dependent on the external variables)	High (typical ratio 6-8)	High (typical ratio 6-8)	Prices change by load level[2]
Advised AD option	Manual (or automated)	Automated	Manual or automated	Manual or automated	Manual (or automated)
Often combined with	CCP		TOU	TOU	

1 According to (Stromback et al., 2011), TOU pilots tend to have peak prices two to four times higher than off-peak prices, whereas CPP pilots tend to have peak prices between six and eight times higher than off-peak prices.

2 In case of consumption based tariffs the rate(s) will increase with consumption. In this case the number of thresholds, the rate per threshold and the timeframe needs to be decided on (e.g. month, week, day).

Complexity of tariff schemes (AlpEnergy, DE)

AlpEnergy Project (DE): The AlpEnergy project developed two different tariff arrangements, both of which are TOU tariffs, but with different levels of complexity (a static pricing model with 2 price levels and no daily update and a more dynamic pricing model with 5 price levels and a daily update). The results of this project imply that a more dynamic tariff is by no means a guarantee for higher load shifting. By using the dynamic pricing model, only 1% of the overall consumption was shifted into the lower-priced time blocks (compared to 2% in the static model). End users billed in the simple pricing mechanism emphasized the importance of an understandable structure of the tariff scheme. End users billed in the more dynamic model criticized the complex structure as being too difficult to translate into action.

More information: http://www.alpenergy.net/

What do you need to do?

The choice and design of an appropriate tariff structure require several steps.

1) Clear definition of the project goal

The project goal will determine the requirements for the chosen tariff structure. For example, a project that aims to structurally reduce the average load level will require a different (combination of) tariff structures compared to a project where the primary goal is the mitigation of extreme and rare events by the use of demand response.

2) Design tariff structure

A selection of relevant tariff structures can be made (see also Table 1), based on the different project goals as defined in step 1. Dependent on the project characteristics, the detailed tariff scheme has to be designed. Therefore, the different dynamics (time blocks, price update frequency) and/or events (type, duration, occurrence) will have to be defined. As a last element, the optimal price spread has to be calculated.

1. **Dynamics**
   a. *Time blocks*: In order to make the tariff structure not too complex for the customer in case of manual response, it is advised to divide each day into a limited number of time blocks (typically between 2-5 time blocks). In the case of automated response, limits on the number of time blocks are in essence determined by the technology. To note that, even though for automated response, the number of time blocks can be higher compared to manual response, there is a risk that the tariff structure will be hard to understand for the customer.
   b. *Price update frequency*: Dependent on the project goal, the frequency of the update has to be adapted. If the scheme aims at changing the routine

behaviour of the end user, prices should not be updated too frequently. On the other hand, depending on the project goal, it might for example be needed to include seasonal effects or even shorter term effects.

2. **Events**
   a. *Type*: Events mostly reflect rare events in the energy value chain (e.g. grid overload), but can also be used by the supplier for marketing purposes (e.g. “Cook your holiday dinner for free” where consumers receive a rebate during holiday periods).
   b. *Duration*: *A* shorter peak period makes it easier for end users to shift load.
   c. *Occurrence*: By definition, extraordinary events occur rarely, e.g. only a few times a year. In addition, it should be defined when these events will be announced.
3. **Price spread**
   The optimal price spread should be carefully determined. On the one hand, the spread should be sufficient to incentivize customers to change their consumption pattern. On the other hand, price differentials that are too large might hinder the adoption by customers as their financial risk is higher. A cap on the highest price zone, a sort of “best price guarantee”, could overcome this process.

3) Customer involvement

In step 2, the different dynamics, events and price spreads are determined. However, it is important to discuss the proposed tariff structure with the targeted customer group, in order to see if the designed tariff structure will generate the expected customer response (for example by conducting a survey). Based on the feedback from end users, the design of the tariff scheme can be optimized. More about consumer involvement is described in the S3C guideline Co-creation – collaborating to develop smart energy solutions.

Discussions with the target group will also allow to take into account the relevant behavioural aspects in the design of the tariff. These aspects are very often location/country-specific (depending on climate, work regime, type of loads, generation mix,…).[3] Electric Vehicle (EV) owners, for example, would typically plug-in their car when they arrive at home in the evening, creating a peak in the local network. In this case an appropriate tariff would incentivise the end-users to charge their car at a later time thereby lowering the burden on the local grid.

[3] See also S3C guideline “Getting to Know your target group”

The customer as major driver for the tariff (KIBERnet, SI)

Kibernet Project (SI): In the Kibernet project, a slightly different approach is considered. The tariff received by the end user for modifying its consumption is in this case either a fixed price defined by the service provider and agreed by the end user or a variable price determined by the end user. In the second option, the end user informs on a daily basis the service provider about the amount of shiftable energy, the time blocks and the relevant price. The service provider then decides if the offer of the end user is economically viable or not. If yes, there can be an activation. In this case, the customer is not only consulted in the design of the tariff, but is even the major driver and responsible of the tariff.

More information: http://www.kiber-net.com/

Do's and don'ts

Some key lessons extracted from current experiences related to the tariff structures discussed above are presented below.

- **Involve the customer in the design of the tariff.** The involvement of customers in the design phase will improve the acceptance of the dynamic pricing scheme as consumer preferences can be taken into consideration.
- **Make sure that tariffs are cost reflective.** Tariffs should aim to really reflect the underlying costs of energy. This will also make it easier for end users to understand prices and to react accordingly.
- **Avoid to implement tariff schemes that are too complex.** Simplicity of pricing schemes is important. Pricing schemes should be easy for the end user to understand, especially in the case of manual response. In case the end-user is being supported by a reliable automated energy system in translating the price signals into actions, more dynamic and complex tariff arrangements become feasible and are even a better fit. See also the best practice example of the AlpEnergy project where a more complex model (supported by automated tools) was not a guarantee for a higher response. This supports the view that, although simplicity requirements become less stringent in the case of automatic control, the end-user should still be able to understand its tariff.
- **Tariffs should provide a proper incentive to customers.** Customers will only modify their consumption pattern in case of sufficient financial gain or other perceived benefits. Therefore, the proposed price spread should be carefully designed. For more information about incentives in general see our guideline Choosing and combining monetary and non-monetary incentives.
- **Stimulate the engagement of customers**. The price spreads between time blocks might not be sufficient to incentivize load shifts or consumption reductions. (A combination of) other incentives might be necessary to stimulate the engagement of the customers. For example, the duration of

events could be shorter to generate a higher response. In addition, it is important that customers understand the tariff.

- **Announce events in a timely manner.** It is important to clearly communicate the expected number of events to the end-users. Moreover, the responsiveness of participants increases when the occurrence of an event is announced timely (e.g. day-ahead).

Further reading

- S3C Deliverable 1.1 (2013). *Report on state-of-the-art and theoretical framework for end-user behaviour and market roles*, 31 October 2013, http://www.s3c-project.eu/Down.asp?Name={HKDBOKAYPM-1128201312241-JMSBZVBBCK}.pdf
  References within D1.1: Stromback et al., 2011; DOE, 2006; Dupont, 2011; EEA, 2013; DECC, 2012; Dütschke, 2013; Breukers & Mourik, 2013
- Dupont,B., et al. (2014). *Demand response with locational dynamic pricing to support the integration of renewables*., Energy Policy, http://dx.doi.org/10.1016/j.enpol.2013.12.058
- Hosschle,H., et al. (2013). *Networked business model for dynamic pricing in the electricity market*, European Energy Market conference (EEM) Stockholm, https://lirias.kuleuven.be/bitstream/123456789/411692/1/eem13_paper.pdf

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 end user 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, end users can take on different positions with respective responsibilities and opportunities. In order to promote cooperation between end users and the energy utility of the future, S3C addresses the end user 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 end user 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.