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POLICY BRIEF

Dynamic Retail Electricity Tariffs: Choices and Barriers

By Pradyumna Bhagwat and Samson Hadush
Florence School of Regulation

Highlights[1]

- Sixteen international case studies on the implementation of dynamic retail electricity tariffs are reviewed to identify the design and implementation choices that have to be made when introducing such tariffs.
- Two primary design choices are identified: 1) the time block length, which means the number of distinct tariff levels; and 2) the price periodicity, which is the time interval between revisions of the tariff. Time-of-use tariffs are widely used and they can be the first step in applying dynamic tariffs before moving to more advanced approaches such as real-time pricing.
- Two types of implementation choices are identified: 1) those made by the regulator regarding regulatory interventions to protect vulnerable customers; and 2) those made by consumers regarding whether to opt for a dynamic tariff and the selection of a suitable dynamic tariff option.
- The implementation of dynamic retail tariffs depends on the availability of physical and information and communication technology (ICT) infrastructure, the maturity of the power market design and consumer behaviour.
- Before implementing dynamic tariffs, it is essential to conduct a careful cost-benefit analysis of the effects on consumers, suppliers and the overall implementation system. Moreover, enabling innovative business models and technologies will help to derive the maximum benefit from the application of dynamic tariffs.

1. This policy brief is based on research conducted by the Florence School of Regulation as part of a more extensive study by the India Smart Grid Forum funded by the Shakti Sustainable Energy Foundation.

1. Introduction

Over the years, dynamic retail electricity tariffs (also known as time-varying tariffs) have been applied in varying forms around the globe, mostly for commercial and industrial consumers but increasingly also for residential consumers.[2] Designing dynamic tariffs at the residential level can be more complicated than for large consumers due not only to significant infrastructure requirements but also to political economy issues surrounding the supply of electricity to individual citizens and households. Nevertheless, dynamic tariffs are becoming more prevalent in order to efficiently integrate more variable renewable energy sources and to manage increasing demand resulting from electrification of the economy such as in the transport sector.

Faruqui and Palmer (2011)[3] define dynamic tariffs as *"charging of different electricity rates at different times of the day and year to reflect the time-varying cost of supplying electricity."* There are various types of dynamic tariffs. The simplest commonly applied variation is a **time-of-use** (ToU) tariff, in which the time blocks and the price corresponding to each time block are periodically revised. The most sophisticated type of dynamic tariff is **real-time pricing** (RTP), in which the price varies following changes in wholesale electricity market prices and with the same time granularity. Between these two extremes there are other types of dynamic tariffs. In **critical peak pricing** (CPP), the customer pays a higher price at specific times during the day or in days during the year when wholesale energy prices are the highest or the grid is exceptionally constrained. In **peak time rebates** (PTR) the customer receives a rebate for reducing the load.[4]

This policy brief examines 16 international applications of household-level dynamic retail tariffs in four continents (see Table 1). The cases have been selected based on the availability of data resulting from a review of the literature and to ensure comprehensive geographical coverage.

In what follows, key design and implementation choices in these international cases are identified and discussed.

Table 1: Summary of case studies[5]

Europe	US & Latin America	Australia & Asia	Africa
•France •Sweden •Norway •Estonia •Finland •Great Britain •Portugal	•California •Connecticut •New York •Brazil	•New South Wales •Victoria •Queensland •Japan	•South Africa

2. Dynamic Tariff Design choices in Practice

The two primary design choices are the time block length and the price periodicity. **Time block length** refers to the number of distinct tariff periods into which a day is divided, i.e. the granularity of the time blocks. For instance, in a real-time pricing approach there will be 24 one-hour time blocks.[6] This type of tariff can be considered to have a short time block length.

Conversely, in a time-of-use approach there may be just two blocks: peak and off-peak or day and night. This can also be considered a short time block length. A tariff with no variation has the longest time block length.

2. Reasons for applying dynamic tariffs have been widely discussed in the literature and so are not repeated in this policy brief.

3. Faruqui, A., Palmer, J., 2011. Dynamic pricing and its discontents, The Brattle Group.

4. See Faruqui, A., Hledik, R., Palmer, J., 2012. Time-Varying and Dynamic Rate Design, Global Power Best Practice Series.

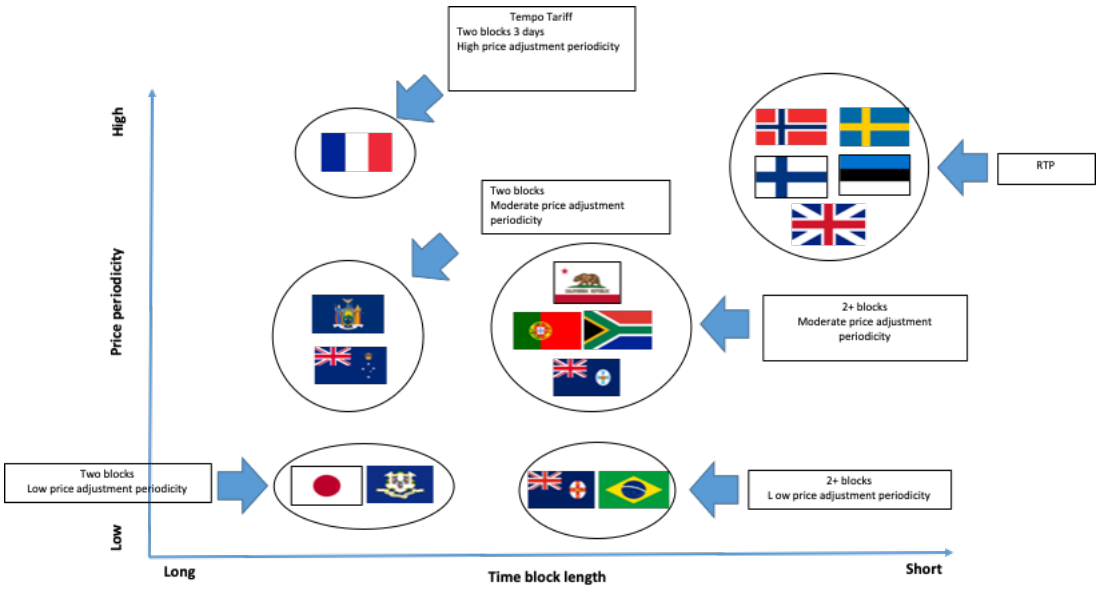
5. A detailed list of references used to develop this analysis is available from the authors on request.

6. Considering one-hour time granularity in the wholesale market.

Price periodicity refers to the time interval between revisions of the tariff. In a real-time pricing approach, the price is updated in advance for each hour of the next day. Hence, the tariff periodicity is high. Conversely, if the tariff is revised annually, bi-annually or for the length of the regulatory period, the price periodicity can be considered medium to low.

The case studies reveal that these two primary design elements are applied in several different ways.[7] Figure 1 illustrates this variation in the (most advanced) retail tariffs available in the different countries/states studied[8].

Figure 1: Primary design choices in the case studies



In this figure, the x-axis represents the time block length, moving from long to a short. For example, a flat tariff would be at the leftmost end of the x-axis, while real-time pricing would be at the rightmost end.

A 2-block approach to time-block length is observed in five cases (Japan, Victoria, France, Connecticut and New York) and tariffs with 3 blocks or more are applied in six cases (Brazil, Portugal, California, New South Wales, Queensland and South Africa). Real-time pricing, which has the shortest time-block length, is adopted in six countries: Great Britain, Finland, Estonia, Norway and Sweden.

The y-axis represents price periodicity. The higher the frequency of price adjustment, the higher the position of the country or state in the chart. For instance, prices that are based on long time horizons such as one year or linked to the regulatory period would be at the bottom of the y-axis, while real-time prices that are updated daily would be at the top.

7. Note that setting the price level is itself a challenge. The price level depends on the market structure and the motivation and goals of the relevant price setter (a retailer in a free market or a regulator).

8. Amongst other references, details regarding dynamic retail tariffs were sourced from the publicly available documents and websites of following organizations: Brazil: ANEEL, California: San Diego Gas & Electric, Connecticut: Connecticut light and power company, Estonia: Eesti Energia, Finland: Fortum, Great Britain: Octopus Energy, Japan: Looop inc, New York: Consolidated Edison Company of New York, Norway: Norges Energi, NSW: Origin Energy, Portugal: ERSE, Queensland: Origin Energy, Victoria: Origin Energy, South Africa: Eskom, Sweden: Vattenfall.

Four cases have low price periodicity and no seasonal variation (Japan, Connecticut, Brazil and Queensland). In six cases (New York, New South Wales, South Africa, Victoria, California and Portugal), a moderate price periodicity is observed. Moreover, in some cases such as South Africa the price can be set over a long time horizon but varied seasonally so they are presented in the middle of the chart. Finally, six countries (Great Britain, Finland, Estonia, Norway, Sweden and France) have high price periodicity. These countries apply real-time pricing,[9] except France, where the 'colour of the day' indicates a low, medium or high electricity price for the day.

Analysis of the most advanced current retail electricity tariff practices at the household level indicates that Norway, Sweden, Finland, Estonia and Great Britain[10] are the most advanced in terms of the application of dynamic tariffs. Retailers in these five countries provide their customers with a real-time pricing option. Apart from these five cases with real-time pricing, all the others have opted for Time-of-use tariffs in various forms. It is interesting to note that California also offers a peak time rebate.

3. Dynamic Tariff Implementation Choices in Practice

Apart from the two primary design elements, two implementation choices need to be made: 1) choices made by regulators, and 2) choices made by consumers. These have direct impacts on the primary design choices.

3.1 Choices made by regulators

The level and method of regulatory intervention have a strong bearing on the dynamic tariff design. These choices remain solely at the discretion of the regulator and depend on its mandate. For instance, regulators may intervene to protect vulnerable customers against price risks or to ensure that consumers are protected from disconnection if a retailer becomes bankrupt or a consumer does not have a contract with any retailer.

As is shown in Table 2, in all the cases some type of regulatory intervention is enforced to protect customers. The most common interventions are designation of a last resort supplier and setting a default tariff. In France, an additional subsidy is provided to poor customers while in Great Britain a price cap is enforced. These interventions can be implemented in combination (e.g. in Great Britain and France).

3.2 Choices made by consumers

The choices offered to consumers can be best discussed from two perspectives: a) can consumers choose whether to opt for a dynamic tariff or not? And b) how many options do consumers have when choosing dynamic tariffs?

The first choice regards the option to choose a dynamic tariff. On the one hand, dynamic tariffs can be made mandatory for all consumers (as in Italy) or an opt-out provision may be provided (e.g. the Californian Utility SDG&E offers customers the choice to opt out of the dynamic tariff structure). On the other hand, consumers may choose among (different) dynamic tariff offerings along with the traditional flat rate (opt-in). The design choice made in this context can have spillover consequences in terms of consumer acceptance of the tariff structure. The second choice relates to the variety of offerings that consumers can choose from. In countries/states with retail competition (all the cases studied except South Africa, Brazil and California), different service providers offer their own variations of

9. According to Crossley, D., 2009. Task 15 – Case Study – TEMPO Electricity Tariff – France, Paris, "In July 2009, EDF discontinued the Tempo tariff for new customers and for customers who are on the tariff at their current residence and then move house."

10. Recently, Octopus Energy in Great Britain has also started providing real-time pricing options.

Table 2: Regulatory interventions related to the implementation of dynamic tariffs

Country	Regulatory intervention
Estonia	The regulator has the right to control prices
France	A regulated tariff option, a subsidy for the energy-poor
Finland	Last resort supplier (DSO)
Great Britain	Retail price caps and last resort supplier
Norway	Last resort supplier (DSO)
Portugal	Last resort supplier
Sweden	Last resort supplier
California	A framework for ensuring adequate supply
Connecticut	Utilities are obliged to provide standard service
New York	Customers are protected under the Energy Consumer Protection Act
Brazil	Default tariffs
Victoria	Default tariffs
Queensland	Last resort supplier
NSW	Default tariffs
Japan	Last resort supplier
South Africa	Last resort supplier

dynamic tariffs. For example, a retailer may offer a choice between time-of-use and real-time pricing. Therefore, depending on their constraints and risk appetites, consumers may choose the most suitable dynamic tariff for their needs.

4. Dynamic tariff implementation barriers

According to the results of a literature review, the implementation barriers which need to be addressed to effectively introduce dynamic tariffs can be broadly classified as: a) physical and information and communication technology (ICT) infrastructure requirements; b) market arrangement requirements; and c) consumer behaviour.[11]

4.1 Physical and ICT infrastructure requirements

The first barrier in the implementation of dynamic tariffs can be an absence of enabling physical and ICT infrastructure. The most basic minimum infrastructure required to implement any kind of dynamic tariff is smart meters. At the network end, smart grid solutions for monitoring network dynamics are required if grid constraints are to be considered in the dynamic tariff design. In addition, ICT solutions to inform consumers about real-time pricing are also required.

4.2 The power market maturity level

The second barrier in the implementation of dynamic tariffs can be a lack of the necessary level of market maturity. For example, the real-time pricing approach is dependent on the energy price dynamics in the wholesale electricity market. The energy price in the wholesale market reflects the cost to the retailer of purchasing energy. This price signal is passed on to consumers. Therefore, the presence of a wholesale market arrangement is required to be able to apply real-time pricing. Time-of-use pricing under dif-

11. A detailed list of the references used to develop this analysis is available from the authors on request.

ferent market structures is discussed by Celebi and Fuller (2012).[12]

4.3 Consumer behaviour

The third barrier to consider is consumer behaviour. For a dynamic tariff to achieve its aims, consumers need to react to the economic signal that is being provided. For instance, if a dynamic tariff is introduced to reduce congestion at a particular time, consumers must react to the price signal and shift load during that time. Therefore, consumers have to have a sufficient level of knowledge and understand the benefits arising from using dynamic tariffs. Joskow and Wolfram (2012) identify this barrier as an unresolved issue.[13]

5. Conclusions

This policy brief has reviewed various international current practices in the implementation of dynamic retail tariffs. Diversity is observed in both the time-varying dimension of tariffs and in implementation choices.

The application of time-of-use tariffs is more commonly observed and can be considered the first step in applying dynamic tariffs before moving to more advanced approaches. With maturity of the electricity market and digitalisation and automation of the operation of the power system, real-time pricing can be applied. This has shorter time granularity, and an energy component of retail tariffs that reflects wholesale electricity price dynamics can be applied.

When dynamic tariffs are introduced, on the one hand regulatory intervention may be required to protect vulnerable consumers. On the other hand, customers may be given a choice to opt in to use a dynamic tariff or to opt out of a default dynamic tariff, and a choice of a suitable dynamic tariff option. In most cases, retail competition has been implemented, which can be considered an enabler providing consumers with a variety of options to choose from according to their needs.

The benefits of dynamic tariffs for consumers, suppliers and the overall system should be carefully assessed and analysed together with the costs. Moreover, innovative business models and technologies that consider consumer behaviour are essential to ensure a responsiveness of residential consumers to the price signals sent through dynamic tariffs.

12. Celebi, E., Fuller, J.D., 2012. Time-of-Use Pricing in Electricity Markets Under Different Market Structures. IEEE Trans. Power Syst. 27, 1170–1181. https://doi.org/10.1109/TPWRS.2011.2180935

13. Joskow, P.L., Wolfram, C.D., 2012. Dynamic Pricing of Electricity. Am. Econ. Rev. 102, 381–385. https://doi.org/10.1257/aer.102.3.381

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Florence School of Regulation
Robert Schuman Centre
for Advanced Studies

European University Institute
Via Boccaccio, 121
50133 Florence
Italy

Contact:
email: fsr@eui.eu website: fsr.eui.eu

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