The Tariff Transition

Considerations for Domestic Distribution Tariff Redesign in Great Britain

Volume I: Final Report

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Summary

As in many countries around the world, the basic structure of domestic distribution tariffs in Great Britain (GB) has remained relatively unchanged for decades. Costs of the distribution system – including the poles, wires, transformers and substations necessary to deliver electricity, as well as the operation and maintenance of this system – have largely been recovered through a simple tariff which includes a "standing charge" (p/day) and a "unit charge" (p/kWh).[1]

The consumer's relationship with the distribution system, however, is changing. In some cases, consumers are installing distributed generation (DG) such as rooftop solar panels. This not only reduces the net amount of electricity that consumers use from the grid, but also introduces the possibility of supplying electricity to the grid. Further, the rollout of smart meters will eventually allow the deployment of new charging structures which were not previously feasible for small consumers. A growing need for flexibility on the demand-side to better integrate renewable generation will also change the relationship between the consumer and the power grid.

These fundamental changes are leading many in the electricity industry to reconsider the design of distribution tariffs. Changing the design of the tariff could potentially offer many benefits in this new environment. But while there is growing momentum toward tariff reform for domestic consumers, there is uncertainty about the shape that the new tariffs will take.

Citizens Advice is the statutory advocate for energy consumers. Part of its role is to scrutinise energy networks' performance and functions. In recognition of both the importance and uncertainty surrounding distribution tariff design, Citizens Advice commissioned The Brattle Group to conduct a study on the landscape of emerging domestic distribution tariff design options, with a particular focus on the impact these new tariff structures may have on consumer bills. The focus of the study is specifically on distribution tariffs for the domestic segment. In conducting this study, Brattle interviewed a diverse group of key industry stakeholders in GB to better understand their views on the issue, developed international case studies of domestic tariff reform activity, surveyed alternative distribution tariff design options, and quantified the bill impacts of the alternative tariff options for a sample of electricity consumers in GB.

Three factors that will influence consumer impacts

Three important factors will determine the extent to which distribution tariff reform could impact consumers in GB. The first factor is the degree to which consumers will be exposed to the structure of the alternative distribution tariff. Currently, each distribution network operator (DNO) charges the suppliers that use its network; suppliers do not have an obligation to pass the structure of the distribution tariff on to their consumers. In the future, if a new distribution tariff structure is introduced and that structure is not passed on to consumers by suppliers in some fashion, then from the consumer's perspective there will be little noticeable impact in their final bill. Alternatively, if the distribution tariff structure is passed on to consumers in some form, then the considerations and opportunities raised in this report become much more relevant to consumers.

[1] Note that, while the structure of the distribution tariff has remained largely unchanged, the methodology that has been used to assign costs to the charges has changed considerably in GB. This is discussed further in Section 2.

The second factor determining the consumer impact of distribution tariff redesign is the future of half-hourly settlement for domestic consumers. Distribution charges paid by suppliers are currently calculated based on an average load profile. Changes in the load patterns of a supplier's customers do not directly impact the profile or the charges paid by the supplier. Therefore, suppliers have little incentive to encourage consumers to modify their electricity usage in a way that will minimize distribution system costs. Settlement that is based on actual consumption would address this issue. Further, from a practical perspective, half-hourly settlement will be necessary to offer some of the alternative tariff designs discussed in this report.

The third factor that will determine the impact of distribution tariff reform on consumers is the share of the consumer's bill accounted for by distribution charges. Distribution charges currently account for only 15 to 20 percent of a domestic consumer's total bill. While significant changes to the distribution tariff could lead to some response from consumers, the price signal would be heavily diluted by non-distribution charges if those did not also change accordingly.

Alternative distribution tariff design options

Our international survey of distribution tariff design options identified four broad ways in which tariffs are being restructured. A higher standing charge or an inclining block rate (IBR) unit charge could be offered with the existing metering infrastructure in GB, while the demand charge and the time-varying unit charge options could not be offered on a full-scale basis until the rollout of AMI is complete and half-hourly settlement is implemented for domestic consumers.

With a **higher standing charge**, the unit charge is decreased proportionally relative to the existing tariff, such that the total revenue collected is the same in the absence of any change in behaviour. The theory behind this approach is that distribution network costs are sunk/fixed in the short run and should therefore be recovered through a fixed charge. Higher standing charges are simple and ensure that a minimum amount of distribution costs are collected from each customer. Common concerns about higher standing charges typically relate to the fact that they would increase bills for small consumers and would reduce the financial incentive to pursue energy efficiency.

A **demand charge** is based on a measure of a customer's peak demand. It is typically introduced as a third charge, alongside the standing and unit charges. The theoretical support for demand charges is that distribution costs are driven much more by distribution system peak demand than by total consumption, so a demand-based charge better aligns prices with costs. Demand charges have been offered to large customers for decades, would present an opportunity to improve economic efficiency in tariff design, and would provide a price signal that would encourage reductions in peak demand. Common concerns about demand charges typically relate to questions about whether customers can understand and respond to the new tariff structure.

Time-varying unit charges would include a higher price during peak hours when there may be capacity constraints on the distribution system, and lower prices during off-peak hours. Time-of-use (TOU) tariffs provide an actionable incentive for customers to reduce bills by changing consumption patterns or investing in energy management technologies. TOU tariffs are already a feature of the standard distribution tariff for large consumers in GB and are an option for domestic customers. Concerns about TOU tariffs largely relate to the ability or interest among customers in responding to the new price signal. There are also concerns that a unit charge is not necessarily an appropriate price signal for recovering demand-driven costs.

Inclining block rates (IBRs) charge consumers a price that escalates with consumption over the course of each billing period. Often, IBRs are designed to charge a lower than average price for a minimal amount of electricity consumption that is deemed necessary for basic services like lighting and refrigeration, and a higher price for consumption associated with "discretionary" electricity consumption. IBRs are generally a policy tool that is used to encourage energy efficiency and reduce bills for small consumers of electricity. Concerns about IBRs often relate to there not being a strong cost-basis for this tariff structure, which could lead to economically inefficient investment decisions.

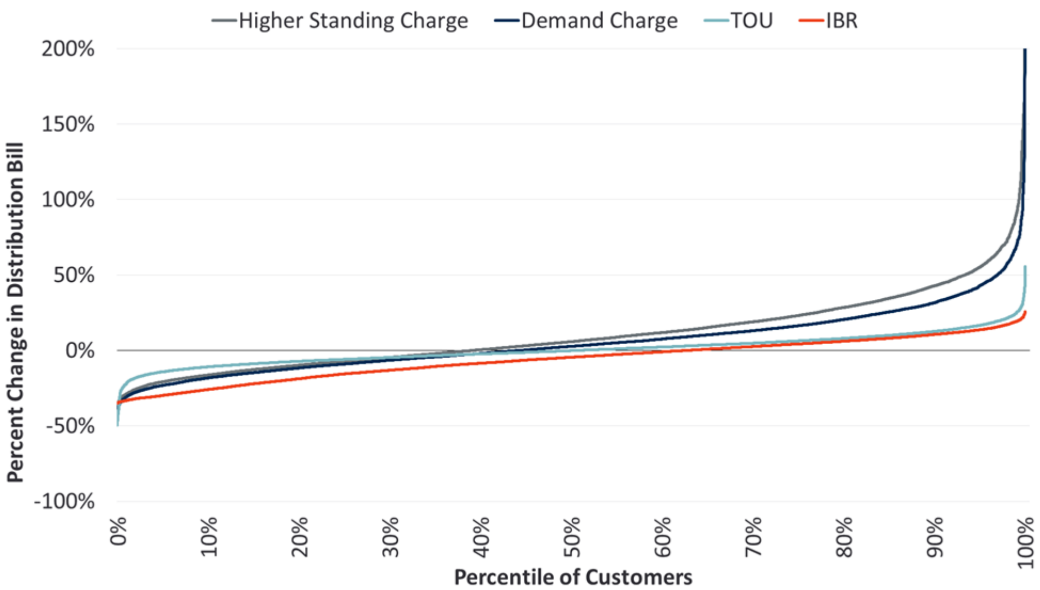
Consumer bill impacts

Bill impacts are a critical consideration when moving to a new tariff structure. To understand how the four alternative tariff designs described previously would affect a range of consumers, we calculated bills using load data for more than 11,000 domestic consumers in GB. Bill impacts were calculated both with and without assumed changes in electricity consumption patterns in response to the new tariff designs. Sociodemographic data allowed for analysis of specific sub-segments of domestic consumers.

The full range of distribution bill impacts for each rate design option is summarized in Figure ES-1. *Importantly, these results are based on an assumption that the change in the structure of the distribution tariff has been passed through from suppliers to consumers.* As described above, there is significant uncertainty around the extent to which the retail tariffs faced by consumers would be modified by suppliers in response to new distribution tariff designs – we include an alternative scenario with muted price signals in Section 7 and the appendices of this report.

Consumers on the left side of the figure are those experiencing bill savings, while the right side of the figure represents the potential range of bill increases. In this static analysis focused only on bill impacts, the IBR structure leads to the greatest share of consumers experiencing bill savings by providing a rate discount to small consumers.[2]

Figure ES-1: Range of Changes in Distribution Bill across Consumers under Alternative Tariffs

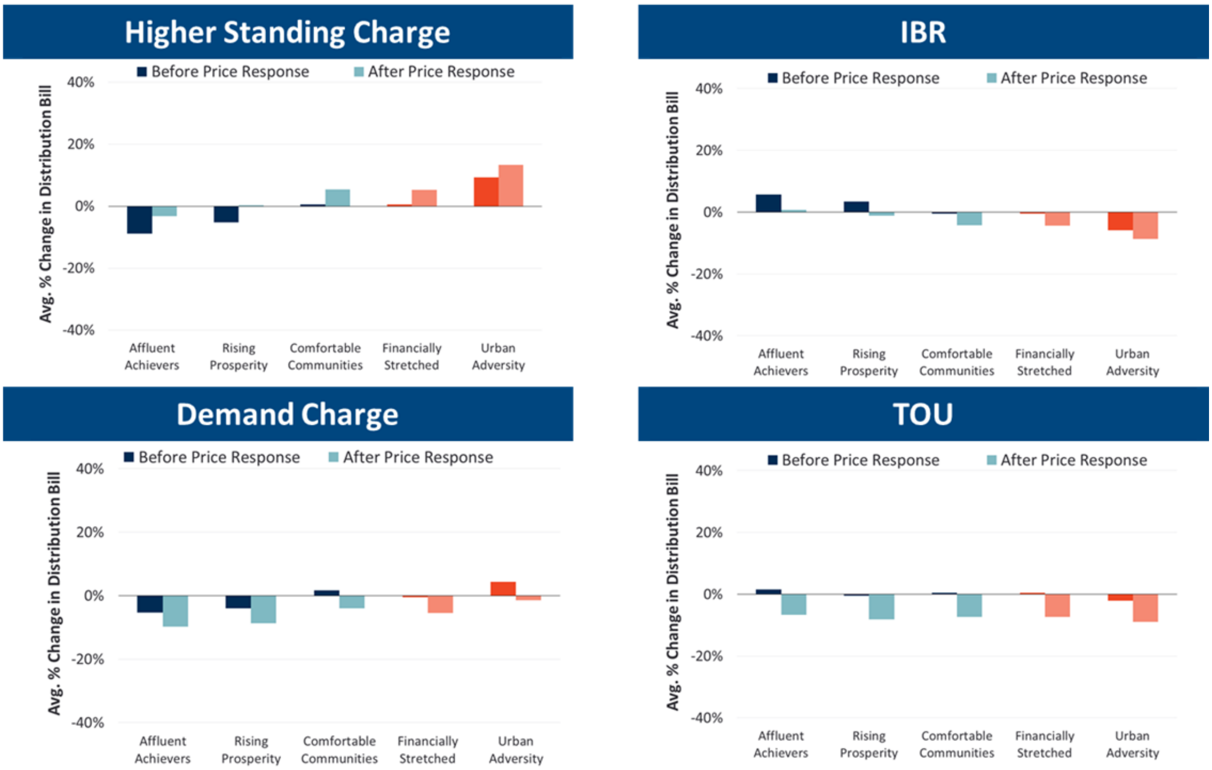


[2] When evaluating the overall merits of a new rate design, impacts on customer bills should be weighed against other important criteria such as economic efficiency, equity/fairness, consumer satisfaction, utility revenue stability and consumer bill stability.

While a static analysis of bill changes is useful for understanding consumer impacts in the absence of price response, evidence suggests that consumers will change their electricity consumption patterns in response to a new tariff design. An international survey of more than 40 domestic pricing pilots conducted over the past dozen years, including several in GB and Ireland, found that in virtually all cases statistically significant peak demand reductions were measured in response to higher peak period prices.[3] If consumers in GB are ultimately exposed to the new distribution tariff designs, this evidence suggests that they are likely to change their electricity consumption patterns in response.

After accounting for price response, all of the alternative tariff options other than the Higher Standing Charge produce average bill savings for low income consumers. In other words, consumers have the opportunity to reduce their electricity bills by managing their electricity consumption. This highlights the value of educating consumers about the new tariff and options that exist for reducing their electricity bill. A summary of bill impacts for the average consumer in various sub-segments before and after price response is illustrated in Figure ES-2.[4]

Figure ES-2: Change in Average Bill, Before and After Price Response



Adoption of rooftop PV will also impact consumers' bills. With largely volumetric retail tariffs, the owners of solar PV systems can virtually zero out their electricity bill while still benefitting from their connection to the grid. Similarly, the solar PV consumer adds little to the total

3 For discussion of an earlier version of this survey, see Ahmad Faruqui and Sanem Sergici, "Arcturus: International Evidence on Dynamic Pricing," *The Electricity Journal*, August/September 2013.

4 It is important to note that customers at the outer ends of the distribution of bill impacts will see savings or bill increases that are significantly larger than the average impacts. See Section 7 and appendix for a description of the consumer sub-segments.

distribution charges paid by their retailer. The distribution utility continues to recover its total investment in the distribution network, despite reduced charges for PV consumers, because unit charges paid by all consumers correspondingly increase. The extent to which this "cost shift" from DG consumers to non-DG consumers will be mitigated by the new distribution tariff will depend on its design.

To illustrate this relationship, we constructed a very simple, stylistic model of distribution system costs. The result of the simple modelling exercise shows that two of the tariffs modelled in this study – the Higher Standing Charge option and the Demand Charge option – significantly reduce the cost shift between PV and non-PV consumers. In contrast, the IBR exacerbates the cost shift by increasing compensation to PV consumers through the higher-priced tier of the IBR. The extent to which the TOU rate addresses the cost shift issue is highly sensitive to the timing of the peak period.

Recent data produced by DECC indicates that there is a strong correlation between income and adoption of rooftop PV.[5] If low income consumers are not among the group of consumers installing PV in the scenario described above, then the price increases associated with the cost-shift would translate into bill increases for those consumers. Therefore, while certain tariff structures such as the IBR appear to be financially beneficial to low income consumers in a static environment without DG adoption, they could have the opposite impact as DG adoption grows.

Making the transition

If GB proceeds with distribution tariff reform and consumers are exposed to the structure of the redesigned tariff, it will be important to develop a tariff transition plan. We have identified seven possible elements for consideration in a future transition:

1. Quantify bill impacts, particularly for low-income consumers, to identify those significantly impacted by the new tariffs and to determine other important but sometimes overlooked factors, such as changes in monthly bill volatility.

2. Assess consumer understanding and acceptance of the new tariffs through market research.

3. Assess consumer response to the new tariff designs through experimental pilots.

4. Establish an open industry dialogue on distribution tariff design, with facilitated and focused discussions on key issues identified in this report.

5. Develop a consumer education plan that is informed by the research activities described above, to improve the likelihood that the tariff is designed to be acceptable to consumers.

6. Consider phasing in the new tariff gradually to reduce the bill impact that would otherwise be experienced by consumers and will give them time to adjust to the new tariff design.

7. Consider protections for vulnerable consumers. With any tariff transition, there is often a strong policy focus on ensuring that vulnerable consumers are not burdened with large bill increases.

[5] DECC, "Identifying Trends in the Deployment of Domestic Solar PV Under the Feed-in Tariff Scheme." https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/79092/5648-trends-deployment-domestic-solar-pv.pdf

Section 1: Introduction

As in many countries around the world, the basic structure of domestic distribution tariffs in Great Britain (GB) has remained relatively unchanged for decades. Costs of the distribution system – including the poles, wires, transformers and substations necessary to deliver electricity, as well as the operation and maintenance of this system – have largely been recovered through a simple tariff which includes a “standing charge” (p/day) and a “unit charge” (p/kWh).

The consumer’s relationship with the distribution system, however, is changing. In some cases, consumers are installing distributed generation (DG) such as rooftop solar panels. This not only reduces the net amount of electricity that consumers use from the grid, but also introduces the possibility of supplying electricity to the grid. Further, the rollout of smart meters will eventually allow the deployment of new charging structures which were not previously feasible for small consumers (but which have been used for larger commercial and industrial consumers for many years). Adoption of electric vehicles, distributed energy storage (such as batteries), smart appliances, and increasing value of flexible demand because of the intermittent nature of renewable generation are also changing the relationship between the consumer and the power grid.

These fundamental changes are leading many in the electricity industry to reconsider the design of distribution tariffs. For instance, Dermot Nolan, Chief Executive of Ofgem, recently stated:

> “There have even been some headlines about a “death spiral” for all electricity grids. If costs continue to fall, the combination of solar PV and battery storage makes it possible for customers to go off the electricity grid altogether…. We need to ensure that whatever happens, our network charging structures are fair and efficient and do not discriminate against any particular group of consumers.”[6]

As further evidence of the importance of this issue, the European Commission recently published a nearly 700 page report on the state of distribution tariff design in countries across Europe.[7] In the U.S. and Australia, tariff reform activities are actively underway, particularly in regions with high levels of DG adoption such as Arizona, California, Hawaii and Nevada. In Hawaii, the problem is particularly acute since one in nine domestic consumers now has rooftop solar panels. According to researchers at North Carolina State University, “Rate design, net metering, and distributed solar ownership are among the most contentious on-going renewable energy policy issues.”[8]

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6 Dermot Nolan speech at Energy UK Annual Conference, 21 October 2015. https://www.ofgem.gov.uk/publications-and-updates/dermot-nolan-speech-energy-uk-annual-conference-energy-customers-future

7 RefE, Mercados, and Indra, “Study on Tariff Design for Distribution Systems,” prepared for the European Commission Directorate-General for Energy, 28 January 2015. https://ec.europa.eu/energy/sites/ener/files/documents/20150313%20Tariff%20report%20fina_revREF-E.PDFhttps://ec.europa.eu/energy/sites/ener/files/documents/20150313%20Tariff%20report%20fina_revREF-E.PDF

8 Benjamin Inskeep, et al., “The 50 States of Solar,” prepared by the NC Clean Energy Technology Center and Meister Consultants Group,” Q3 2015. https://nccleantech.ncsu.edu/wp-content/uploads/50-States-of-Solar-Q3-FINAL_25.pdfhttps://nccleantech.ncsu.edu/wp-content/uploads/50-States-of-Solar-Q3-FINAL_25.pdf

Changing the design of the tariff could potentially offer many benefits in this new environment. It could help to encourage the efficient adoption of emerging cost-effective energy technologies while improving fairness in cost recovery, through charges that are more closely aligned with system costs. But while there is growing momentum toward tariff reform for domestic consumers, there is uncertainty about the shape that the new tariffs will take. This uncertainty is particularly prevalent in GB, where the adoption of distributed energy resources (DERs) is growing quickly.

Citizens Advice is the statutory advocate for energy consumers. Part of their role is to scrutinise energy networks' performance and functions. In recognition of both the importance and uncertainty surrounding this issue, Citizens Advice commissioned The Brattle Group to conduct a study on the landscape of emerging domestic distribution tariff design options, with a particular focus on the impact these new tariff structures may have on consumer bills. In conducting this study, Brattle interviewed a diverse group of key industry stakeholders in GB to better understand their views on the issue. The study also includes international case studies of domestic tariff reform activity, a survey of alternative distribution tariff design options, and a detailed quantitative analysis of the bill impacts of the alternative tariff options for a sample of electricity consumers in GB.

There are a few caveats to be noted about the scope of this study. First, the study focuses on domestic electricity consumers, not the natural gas sector or non-domestic consumers. Second, the focus of the study is the *structure* of the various charges in the distribution tariff, not the total amount of revenue collected. Third, the geographic scope is limited to Great Britain (though many of the concepts discussed in this report are applicable to jurisdictions as well).[9] Finally, it is worth noting that some of the tariff structures examined in this study have been utilized in other regions to recover the costs of generation capacity and transmission network capacity. Even if these tariff structures have not been used explicitly to recover *distribution* capacity costs, the capacity-related nature of these charges makes them relevant to the discussion.

The remainder of the report is organized as follows: Section 2 discusses global drivers of interest in distribution tariff reform. Section 3 discusses the state of distribution tariff design in GB. Section 4 summarizes stakeholder views on distribution tariff design. Section 5 presents alternative distribution tariff design options and their advantages and disadvantages. Section 6 includes several case studies from other jurisdictions where significant domestic tariff reform activities are taking place. Section 7 includes a quantitative assessment of the impact of the alternative tariff designs on consumer bills. Section 8 concludes with key findings and recommendations. The introduction to each section includes a brief summary of the section's highlights.

[9] Northern Ireland and the Republic of Ireland are part of a separate unified energy market (the Single Energy Market, or SEM), with their own regulatory/policy framework.

Section 2: The current state of distribution tariffs in GB

Section 2 highlights:

- A common methodology is used to establish distribution charges across all distribution networks in GB
- The magnitude of distribution charge tariffs levels varies across each of the 14 regional distribution networks because each network has different costs
- The standard distribution tariff is composed of a modest standing charge and a unit charge
- Each distribution utility network charges the suppliers that use its network; suppliers do not have an obligation to pass the structure of the distribution tariff on to their consumers
- The distribution bill accounts for only 15 to 20 percent of a domestic consumer's total bill
- Distribution charges are calculated based on an average load profile; half-hourly settlement on an individual consumer basis is not currently used for domestic customers

THE REGULATORY PROCESS

As context for the discussion of distribution tariff design in GB, it is helpful first to understand the process by which distribution tariffs are set. The total revenue that each distribution network can collect is set by Ofgem, but the tariff is set by the distribution utilities (also known as distribution network operators, or DNOs). Prior to 2010, each DNO in GB developed its own distribution tariff, subject to review and approval by Ofgem. The methodologies used to develop these tariffs differed across the utilities, with seven different methodologies being implemented at the time.

In 2010, in the interest of establishing uniformity in the way distribution tariffs are developed and reported across GB, the Common Distribution Charging Methodology (CDCM) was developed.[10] The CDCM ensures that all DNOs calculate distribution tariffs using the same methodological framework. The CDCM is codified in the Distribution Connection and Use of System Agreement (DCUSA).[11] Parties to the DCUSA meet regularly to discuss distribution charging issues.[12] Modifications to the CDCM (known in the industry as "mods") can be proposed by these parties at any time and are subject to approval by Ofgem following review and recommendation by a DCUSA review panel. There have been over 200 mods since the inception of the CDCM, largely to address issues that were left unresolved at the time the CDCM was established. Thus far, the mods generally have not focused on the structure of the tariff design.

While the methodology for setting distribution tariffs is the same across all DNOs, the magnitude of the distribution charges varies from one utility to the next.[13] This is because the utilities have

10 See Ofgem website for details: https://www.ofgem.gov.uk/electricity/distribution-networks/charging-arrangements

11 DCUSA website: https://www.dcusa.co.uk/SitePages/Home.aspx

12 For more information on the Distribution Charging Methodologies Forum, see the Energy Networks Association website: http://www.energynetworks.org/electricity/regulation/distribution-charging/distribution-charging-working-groups.htmlhttp://www.energynetworks.org/electricity/regulation/distribution-charging/distribution-charging-working-groups.html

13 For discussion of regional differences, see Ofgem, "Regional Differences in Network Charges," October 25, 2015. https://www.ofgem.gov.uk/publications-and-updates/ofgem-report-regional-differences-network-charges

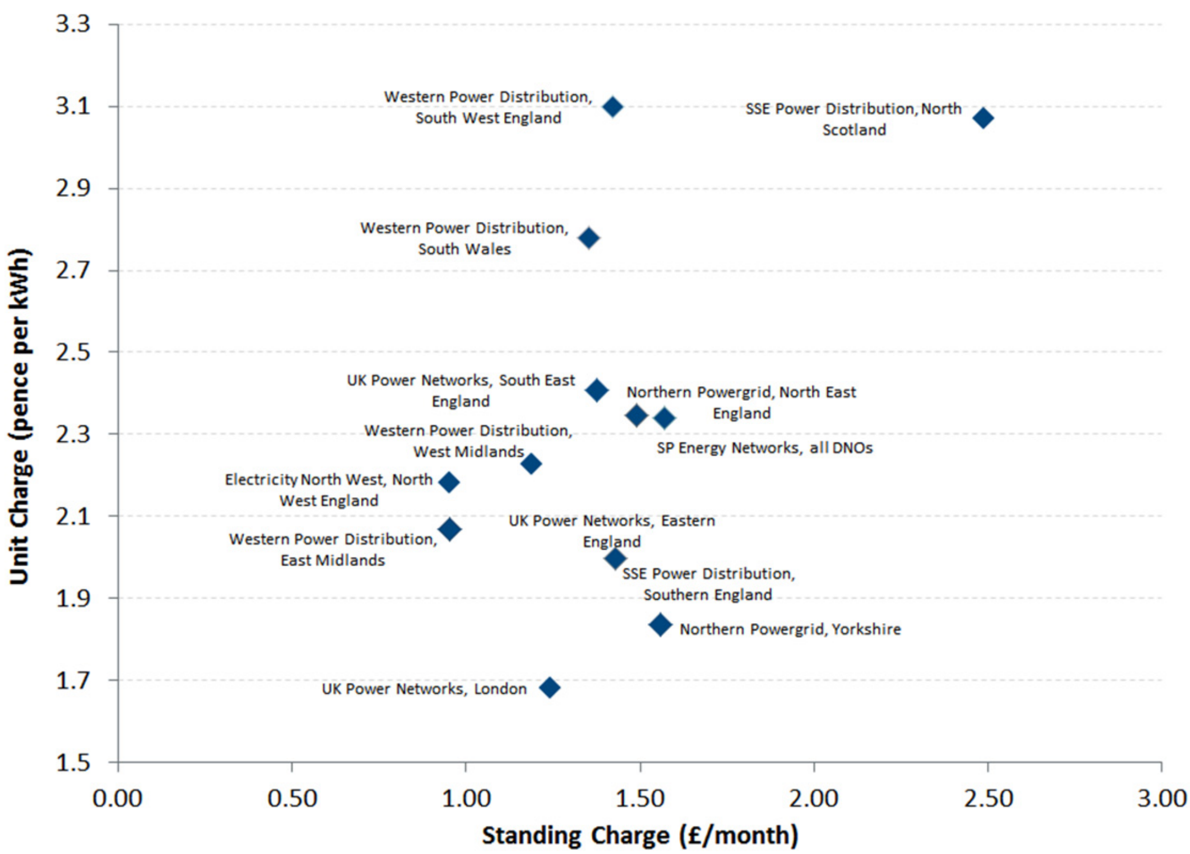
different costs, depending on the characteristics of their distribution system. Some DNOs, for example, have a geographically dispersed network predominantly in rural areas, with long distribution lines connecting consumers, whereas others have a denser urban network. Topography and age of the existing infrastructure are some of the factors that can cause differences in distribution charges across the DNOs.

CURRENT DISTRIBUTION CHARGES

Domestic consumers in GB have a two-part distribution tariff.[14] This is referred to as the "Domestic Unrestricted" tariff. It is composed of a standing charge (p/day) and a unit charge (p/kWh). Proportionally, the standing charge is relatively small, with the majority of domestic distribution revenue being recovered through the unit charge. Some consumers (roughly 20 percent) are on a tariff with a higher unit charge during peak hours of the day and a much lower unit charge during off-peak hours (in addition to a standing charge). This is referred to as the "Domestic Two Rate" tariff.

The standing and unit charges in the Domestic Unrestricted tariff for each of the DNOs in GB are summarized in Figure 1. Note that the standing charge has been converted to pounds per month.

Figure 1: Unit and Standing Charges in Domestic Distribution Tariffs



Source: DNO Charging Statements, effective date 1 April 2017.

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14 The technical term in GB is Distribution Use of System (DUoS) charges. In this report, we use the more general terminology of a "distribution tariff" which is composed of "distribution charges."

For a typical domestic consumer with roughly 3,100 kWh of electricity consumption per year (260 kWh per month), the annual distribution bill amounts to around £85 per year (£7.10 per month). **This distribution bill is only 15 to 20% of the consumer's total electricity bill**.[15] The rest of the bill includes generation costs, transmission costs, various policy costs (e.g., renewables subsidies), and supply costs. A review of national data suggests that the typical total domestic electricity bill includes roughly a £5.75/month standing charge and a £0.14/kWh unit charge. This amounts to a total annual electricity bill of around £500 (£42 per month) for a typical consumer.

SETTLEMENT

In GB, domestic consumers are not billed by the DNO. Instead, suppliers pay the distribution charges to the DNO. Suppliers receive a bill from each DNO which represents the supplier's use of the network to supply all of its customers on that network in aggregate. How those charges are passed on to the consumer is entirely at the discretion of the supplier. From the supplier's perspective, the distribution charge is a cost like other costs such as purchasing electricity in the wholesale market. For instance, if the supplier decided to offer consumers a very simple tariff composed only of a single unit charge, the supplier would not be obligated to include the distribution standing charge in the design of that tariff. Currently, the structure of domestic tariffs offered by suppliers is generally consistent with the two-part nature of the distribution charge. However, that would not necessarily need to continue to be the case. As will be discussed later in this report, this framework has implications for the extent to which changes in the distribution tariff design will reach the end consumer.

Settlement of distribution charges between the supplier and the DNO is currently based on an average load profile for domestic consumers. The actual half-hourly consumption of a supplier's customers on a given tariff are assumed to add up to this average load profile. In general terms, scaling up the average consumer load profile by the total electricity consumption of the consumers served by a given supplier produces the aggregate profile upon which the supplier's total distribution bill is settled. While the load profiles are derived empirically from a sample of actual consumer load data, it is certainly possible and even likely that a given supplier's customer base has an aggregate load shape that differs from this profile. Changes to the load shape of the supplier's customers will not proportionally change the load shape upon which the distribution charges are settled. This reduces the incentive for suppliers to offer tariff structures that will encourage consumers to shift consumption away from high-cost hours on the distribution system in ways that lower total distribution system costs.

This load profile-based settlement approach could change with the rollout of smart meters in GB. By collecting electricity consumption data over short time intervals (e.g., 30-minute increments) for each individual consumer, it will be possible to offer new tariff designs that are time-varying or based on a measure of the consumer's peak demand. With enhanced data collection and billing systems, it will also be possible to move away from settlement based on load profiles and instead charge on the basis of each individual consumer's usage pattern. This is referred to as "half-hourly settlement" and is the approach used for large (non-domestic) consumers. The timing and extent to which half-hourly settlement will be implemented in GB is currently being explored among industry stakeholders.[16]

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[15] Note that if peak demand-related distribution network costs were recovered through the tariff only during peak hours, then the distribution charge would represent a higher share of the total bill during those hours.

[16] For more information, see: https://www.ofgem.gov.uk/electricity/retail-market/market-review-and-reform/smarter-markets-programme/electricity-settlement

Section 3: Drivers of Distribution Tariff Reform

Section 3 highlights:

- Adoption of rooftop solar is the most significant driver of tariff reform internationally; concerns about fairness in cost recovery are at the root of this issue
- Smart meters with half-hourly settlement will enable the deployment of new tariff designs which were previously infeasible in GB
- There is interest in using innovative tariff design to encourage changes in electricity consumption patterns that defer the need for investment in distribution system upgrades
- Tariff design can also facilitate the adoption of "flexible" resources such as demand-side response and distributed energy storage to assist with the grid integration of renewables

INTRODUCTION

A number of factors have converged globally to lead regulators, utilities and their stakeholders to consider modifications to domestic tariff design. The following are the key drivers observed internationally, with brief discussion of their role in GB.

DISTRIBUTED GENERATION ADOPTION

The adoption of DG, rooftop solar in particular, has been perhaps the most significant driver of global interest in domestic tariff reform. This is largely due to concerns among utilities that consumers with rooftop solar may not be fully paying for their use of the grid, leading to inefficient investment in DG as well as over-collection of network costs from consumers who do not have DG.

When consumers install rooftop solar photovoltaic (PV) panels, their net monthly usage decreases. For instance, consider a consumer with 500 kWh of monthly electricity usage. That consumer could install a 6 kW solar PV system which might produce 440 kWh of electricity during the month, bringing his or her average net electricity usage down to 60 kWh per month.[17] While this consumer uses very little electricity in total over the course of the month, the consumer is typically using significant amounts of electricity from the grid during times when the sun is not shining. The consumer is also pushing electricity on to the grid when the PV system produces more than he or she consumes. Under DG compensation policies such as net metering, this consumer is only charged for the 60 kWh of net monthly usage, which does not fully cover the cost of his or her use of the distribution system.

Compounding this issue is the challenge from a social policy perspective that lower income households are less likely to be able to afford the purchase of a rooftop PV system, have the credit record necessary to sign a long-term lease for the solar panels in regions where that option is available, or even have a roof on which to install them for that matter. At the same time, however there is a strong policy push in GB to decarbonize the electricity sector in large part through adoption of renewables. Some utility companies believe that new tariff designs could potentially more fully recover distribution costs from DG consumers while still remaining consistent with a given region's clean energy policy goals.

[17] This assumes an illustrative 10% capacity factor for rooftop PV in GB.

The current rooftop PV compensation policy in GB is particularly favourable to consumers with rooftop PV. Consumers are billed based on their consumption net of 50 percent of the output of their PV system, allowing consumers to avoid paying the full retail tariff for half of the kilowatt-hours of generation from their PV system. Consumers receive a seprate payment for the other half of their on-site generation, which represents an estimate of the electricity that they have exported to the grid during the billing period (i.e., the electricity they did not consume on-site). In addition to these two payments, output from the PV system is separately metered and consumers receive an additional separate payment for all of the electricity that they generate. This payment is commonly referred to as a feed-in tariff (or FIT).[18]

Solar PV adoption in GB is growing quickly. As of February 2016 there were approximately 3.2 GW of domestic solar capacity installed in GB, representing roughly 36% of all GB solar capacity[19] and 4.6 percent of a total installed generation capacity base of 70 GW.[20] Growth in PV adoption has significantly exceeded forecasts, and recent projections suggest that installed PV capacity could reach [14] GW by 2020.[21] This growth is driven in part by declining costs. The UK PV industry achieved cost reductions of nearly 70% between 2010 and 2015, and a further 35% reduction is expected between 2015 and 2020.22 Adoption of rooftop PV can increase quickly as costs decline.

THE ROLLOUT OF SMART METERS

Smart meters can record an individual consumer's electricity usage on a half-hourly basis. While this type of information has long been collected for larger consumers, the deployment of smart meters for domestic consumers in various regions around the world began to accelerate only in the past 10 to 15 years. With this information, new tariff designs can be offered which were previously infeasible. For instance, with smart meters it is possible to know a given consumer's demand during the hour or hours when the power system or distribution grid is peaking. A charge could be levied based on this peak-coincident demand to better reflect the extent to which the consumer is contributing to capacity costs. This is just one of many examples of a new charging structure that could be offered with smart meters.

Smart meters have begun to be rolled out by suppliers in GB. A target date of 2020 has been established for full deployment of the meters to all households. The speed with which this new metering infrastructure will facilitate innovative new tariff offerings will be determined by the resolution of the half-hourly settlement debate described in Section 2. Figure 2 illustrates the planned rollout of smart meters in GB. [23]

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18 For a description of the compensation options available to domestic PV customers, see: http://www.energysavingtrust.org.uk/domestic/feed-tariffs-0

19 "Solar photovoltaics deployment in the UK, January 2016," *Department of Energy & Climate Change*, 25 February 2016, and "Feed-in Tariff Annual Report 2014-15, *Ofgem*, 16 December 2015, p. 20. These calculations assume that all residential solar capacity is FIT (feed-in tariff). The DECC report estimates approximately 3,332 MW of FIT capacity in the GB in December 2015, and Ofgem estimates that, as of March 2015, approximately 96% of FIT solar installations were domestic.

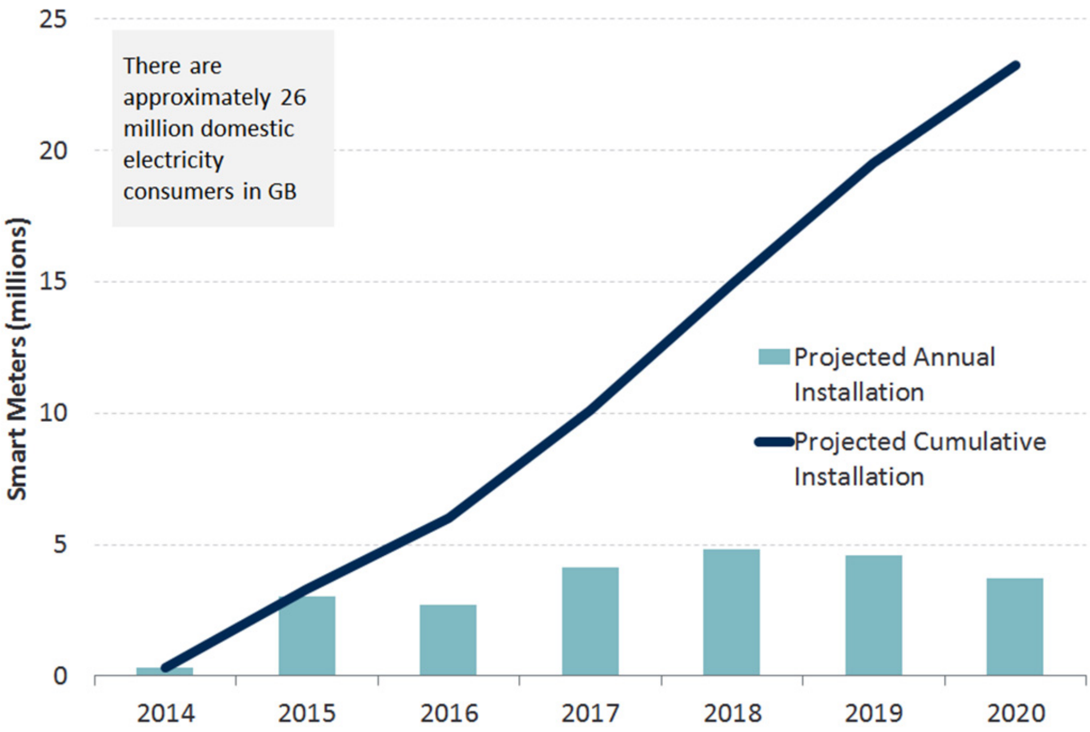
20 Total GB generation capacity is assumed to be 70 GW, as per National Grid's estimate in late 2015. "Winter Outlook Report 2015/16," *National Grid*, 2015, 15.

21 "UK solar beyond subsidy: the transition," *KPMG*, July 2015, p. 29.

22 Ibid, p. 4.

23 These projections are from a February 2014 plan. More recent estimates of smart meters currently installed indicate that the rollout may not meet original deadlines.

Figure 2: UK Domestic Smart Meters, Projected Installation



Source: "Study on tariff design for distribution systems: Final Report," Ref E, AF Mercados EMI, and Indra Sistemas, January 28, 2015.

MITIGATING DISTRIBUTION SYSTEM COSTS

In response to aging grid infrastructure and rising distribution system costs, many utilities and regulators have begun to explore ways in which to avoid or defer the need for new investment in the distribution system. Demand-side response through the use of smart thermostats or grid-interactive water heaters, peak-focused energy efficiency measures, the deployment of batteries, or PV adoption (to the extent that PV production coincides with distribution system peak demand) can help to reduce peak demand and therefore defer the need for upgrades in grid capacity costs. Charging structures that encourage consumers to shift electricity demand away from capacity-constrained times of day can help to facilitate the adoption of these measures.[24]

As is the case in other regions of the world, exploring the use of demand-side resources to defer distribution system investment is in the early stages in GB. As part of the Low Carbon Networks Fund, a number of trials have been conducted in GB to test the technical feasibility of a range of demand-side technologies and initiatives that can help to manage the distribution network and relieve congestion.[25] Similarly, the Electricity Network Innovation Allowance and Electricity Network Innovation Competition both currently provide funding opportunities for distribution-

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[24] See Ahmad Faruqui, Dan Harris, and Ryan Hledik, "Unlocking the €53 Billion Savings from Smart Meters in the EU: how increasing the adoption of dynamic tariffs could make or break the EU's smart grid investment," *Energy Policy*, October 2010.

[25] Ofgem website: https://www.ofgem.gov.uk/electricity/distribution-networks/network-innovation/low-carbon-networks-fund

level projects.[26] Given the amount of investment that is needed to maintain and upgrade the GB distribution system, it would not be surprising to see activity ramp up in this area. DNOs spent £15 billion managing and improving the reliability of their distribution systems between 2010 and 2015, representing a 12 per cent increase in costs relative to the prior five year period.[27]

INTEGRATING INTERMITTENT SOURCES OF GENERATION

Much of Europe has committed to decarbonisation of the power grid and increasing quantities of renewables electricity generation. This will lead to increased adoption of clean but intermittent sources of generation like wind and solar, raising new integration challenges. For instance, flexible resources will need to be available to respond when the wind stops blowing or the sun goes behind a cloud. At other times, consumption may be beneficially shifted to times of day when there otherwise may be a surplus of wind or solar generation. There is growing interest in the potential to provide this capability through a combination of new tariff structures and automating technologies like smart thermostats or battery storage (either standalone batteries or those in electric vehicles).

Improving grid flexibility is an area of focus in GB. DECC recently issued a report describing the barriers to greater adoption of flexible demand-side resources and laying out several areas in which the development of new policies will help to overcome these barriers.[28] The report highlights the role that new tariff structures could play in promoting demand-side response. Similarly, Ofgem published a position paper in September 2015 on ways to improve the flexibility of the energy system and is analysing the extent to which distribution tariffs facilitate flexibility in demand.[29]

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26 Ofgem website: https://www.ofgem.gov.uk/network-regulation-riio-model/network-innovation/electricity-network-innovation-competition and https://www.ofgem.gov.uk/network-regulation-riio-model/network-innovation/electricity-network-innovation-allowance

27 Ofgem, "Electricity Distribution Company Performance," 16 December 2015. https://www.ofgem.gov.uk/sites/default/files/docs/electricity_distribution_company_performance_2010-2015.pdf

28 Department of Energy & Climate Change, "Towards a Smart Energy System," 17 December 2015. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/486362/Towards_a_smart_energy_system.pdf Department of Energy & Climate Change, "Towards a Smart Energy System," 17 December 2015. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/486362/Towards_a_smart_energy_system.pdf

29 Ofgem, "Making the Electricity System More Flexible and Delivering the Benefits for Consumers," 30 September 2015. https://www.ofgem.gov.uk/publications-and-updates/position-paper-making-electricity-system-more-flexible-and-delivering-benefits-consumers

Section 4: Stakeholder Perspectives

<u>Section 4 highlights:</u>

- Perspectives were gathered from a diverse group of industry stakeholders in GB
- Most agree that distribution tariff reform is becoming an increasingly important issue
- In GB, perhaps the most significant driver of interest in distribution tariff redesign is a desire to facilitate adoption of "flexible" resources like energy storage
- A key challenge identified in distribution tariff design is the need to balance economic efficiency and cost-reflectivity with other considerations such as simplicity, bill/price stability, and protections for vulnerable customers
- There are a number of alternative tariff designs that are of interest to stakeholders, though there do not yet appear to be firmly entrenched positions on this issue

Introduction

To capture the range of stakeholder perspectives on distribution tariff design, we conducted a series of interviews with a diverse set of organizations. The interviews were conducted by phone or in-person and covered a range of issues including objectives for distribution tariff design, changes that may be needed to the current distribution charging structure, and the regulatory process for modifying distribution tariffs. The questionnaire provided to each interviewee is included in Appendix A. We spoke with:

- British Gas (Supplier)
- DECC (Government)
- Green Hedge (Solar and storage developer)
- National Energy Association (Consumer advocacy)
- Northern Powergrid (DNO)
- Ofgem (Energy regulator)
- Sustainability First (Environmental advocacy)
- Tempus Energy (Supplier and demand-side response aggregator)
- Western Power (DNO)

The following is our interpretation and synthesis of what we heard in the interviews. We have highlighted general themes of the conversations, though it is not necessarily the case that there was consensus on these issues.

Reasons to Modify the Distribution Tariff Structure

Stakeholders generally agreed that distribution tariff design has not yet been an area of high activity in GB, but is on the cusp becoming an important issue. In the six years since the CDCM was developed, most distribution tariff reform activity was related to "cleaning up" various unresolved issues in the CDCM. The frequency of these refinements to the CDCM appears to be waning, which could free up resources to focus on the tariff design challenges described in this report. The Competition and Markets Authority's (CMA's) investigation into retail market competition is also believed to have caused some to hold off on tariff reform efforts while waiting for an outcome of the investigation. The statutory deadline for a final decision in that matter is 25 June 2016 and will resolve some of this uncertainty.[30]

While stakeholders largely agree that distribution tariff design is likely to become an important issue in GB, there is less agreement regarding the reasons for its importance. Some stakeholders suggested that too much revenue is currently being collected through the unit charge. Some highlighted that this does not provide an incentive for consumers to shift consumption away from peak hours and suggested that a time-varying unit charge would be more appropriate. Another stakeholder suggested that a portion of the revenue collected through the unit charge should instead be collected through the standing charge in recognition of the fact that distribution system costs are fixed in the short run.

Several stakeholders also highlighted the challenge that the current rooftop PV compensation structure under-recovers distribution grid costs from PV-owners. The nature of this concern was not one of cost recovery – most feel that DNOs will be provided enough revenue to cover their costs. Rather, the concern was one of equity and fairness in whom those costs are recovered from. There was some concern that the subsidization of those with DG by those without, while small in GB today, could grow to unsustainable levels in the future.

Another significant driver of interest in distribution tariff redesign is a feeling that the current structure does not provide adequate incentives for the adoption of distributed energy storage. The perception is that there is a growing need for flexible demand and the ability to shift load, and that current structures do not accurately reflect this need. For instance, the flat (i.e. non-time-varying) variable nature of the unit charge means that suppliers do not have a financial incentive to encourage consumers to shift load. Further, the lack of variation in distribution charges within a given DNO service territory does not encourage efficient adoption of demand-side resources in locations with distribution capacity constraints.

TARIFF DESIGN OBJECTIVES

Stakeholders identified a number of key objectives for designing distribution tariffs. Virtually all stakeholders agreed that cost-reflectivity was the principal goal for tariff design. Tariffs should be designed to accurately reflect the underlying costs that they are designed to collect. The challenge – and where there is disagreement among stakeholders - is the extent to which this objective should be sacrificed for other considerations that they also deem to be important.

Several stakeholders identified price and bill stability as one such important consideration. Any change in the tariff design will cause some consumers' bills to increase and others to decrease. As is illustrated in Section 7 of this report, the magnitude of these changes could be significant for some consumers. Developing a transition plan that introduces the new tariff structure gradually, to avoid dramatic changes in consumer bills, was identified as an important activity in this regard.

Stakeholders also highlighted the tension between designing tariffs that encourage demand-side response and the adoption of emerging energy technologies, while at the same time maintaining a degree of simplicity and transparency. Some stakeholders suggested that consumers have a limited degree of interest in their electricity bills and would not take the time to understand a very complex tariff structure. On the other hand, other stakeholders pointed to recent dynamic pricing pilots in GB as evidence that consumers are able to understand new tariff designs and will

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30 For more information about the CMA's investigation, see https://www.gov.uk/cma-cases/energy-market-investigationhttps://www.gov.uk/cma-cases/energy-market-investigation.

respond by changing their electricity consumption patterns. In spite of the findings of these pilots there was a lack of consensus regarding the degree to which consumers will respond to new tariffs. One stakeholder pointed out that emerging technologies such as smart thermostats and battery storage could automate demand reductions in a way that would not require consumers to understand the details of the new tariff in order to benefit from it.

Fairness, and the affordability of electricity for vulnerable consumers, were also identified by most stakeholders as key policy considerations. Some stakeholders suggested that, if new tariff designs were to lead to untenable bill increases for this consumer segment, tariff exemptions could be made to provide qualifying consumers with a bill discount or the option to enrol in an alternative tariff. One stakeholder suggested that, in an effort to make electricity affordable for low income consumers, they could be exempt from the distribution charge entirely. Since consumers do not pay the distribution charge directly, presumably this could be addressed through the creation of a separate class of distribution consumers or would require that suppliers offer the discount through a tariff designed specifically for qualifying consumers.

Technical feasibility of the new tariff designs was also highlighted as an important consideration. Most stakeholders agree that half-hourly settlement will happen for domestic consumers, and it is only a question of when this will occur. But until this happens, deployment of many of the distribution tariff designs that are of interest will remain infeasible. Technical and cost barriers to implementing half-hourly settlement will need to be overcome before it is in place.

ALTERNATIVE TARIFF DESIGN OPTIONS UNDER CONSIDERATION

Stakeholders identified several new tariff designs that were either already in deployment, under consideration, or otherwise deemed appropriate for future efforts to reform distribution tariff design. Generally, however, there did not appear to be very strongly held beliefs about new designs that should or should not be offered. Relative to some other regions where stakeholders already have entrenched views on these issues, GB appears to be starting from a "blank slate".

Increasing the standing charge, with a commensurate reduction in the unit charge, was discussed as a possibility. One suggestion was to recover half of distribution revenues through the standing charge and the other half through the unit charge (as opposed to the 20 percent standing charge / 80 percent unit charge split that exists in the existing tariff) in recognition that distribution costs are largely fixed in the short run. It was suggested that this would also improve the predictability of the price for suppliers, who are otherwise subject to uncertainty in both the price of the unit charge as well as sales volume. Another stakeholder pointed out that a higher standing charge would be a regressive policy penalizing small consumers.

The ability of time-varying and dynamic tariffs to reduce peak demand was highlighted frequently as a potential benefit of tariff redesign. One stakeholder pointed to a pilot tariff in southwestern GB with lower mid-day prices designed to encourage consumption increases during hours when solar production is high. In constrained portions of the grid, this could avoid curtailing a zero-emission, low variable cost source of generation. Another pointed to a 'Free Saturdays' tariff being offered by a supplier, though noted that this is likely driven more by a competitive attempt to gain market share than to reflect costs.

In addition to making tariffs time varying, it was also suggested that prices could vary locationally. While charges vary from one DNO to the next, they do not vary within a given DNO's service territory. Recognizing local capacity constraints on the distribution system through distribution charges could lead to the deferral of distribution capacity investment.

Section 5: Alternative Distribution Tariff Design Options

Section 5 highlights:

- The key principles of tariff design include economic efficiency, equity, revenue adequacy/stability, bill stability, and customer satisfaction
- Four common categories of alternative distribution tariff designs have emerged internationally; two require half-hourly settlement and the other two do not
- Demand charges have a robust precedent in tariffs for large customers and can be implemented to better align prices with the primary driver of grid capacity investment
- Time-varying unit charges provide an actionable incentive for customers to reduce bills by changing consumption patterns or investing in energy management technologies
- Higher standing charges are simple and ensure that a minimum amount of distribution costs are collected from each customer
- Inclining block rates are a policy tool that is used to encourage energy efficiency and reduce bills for small consumers of electricity
- In addition to the design of the new tariff, there are important considerations regarding the way in which it is deployed to consumers

PRINCIPLES OF TARIFF DESIGN

Before discussing alternatives to the current distribution tariff design in GB, it is helpful to establish a set of core principles for sound tariff design. There is an extensive library of academic literature on principles of tariff design, explaining that there are trade-offs that prevent each from being perfectly satisfied without sacrificing others. Overall, the literature is similar in its agreement that tariffs should reflect costs and recover those costs from consumers in a way that accurately represents their use of the system. The literature varies in its emphasis on specifics. Some focus largely on the most appropriate way to reflect costs through tariffs, while others account for additional considerations in regulation, such as simplicity, stability and public acceptability. Overall, the literature is consistent with the key considerations in tariff design identified by industry stakeholders, as summarized in Section 4 of this report.

Based on our review of the literature, we have distilled the recommendations to five specific principles for distribution tariff design: economic efficiency, equity/fairness, consumer satisfaction, utility revenue stability and consumer bill stability. In addition to satisfying these principles, there may be important additional social policy considerations, such as mitigating the impact of the rates on vulnerable consumers. Section 8 identifies a number of ways in which this consideration can be addressed through a well-designed tariff transition plan.

Economic efficiency: The price of electricity should convey to the consumer the cost of delivering it, ensuring that resources committed to the delivery of electricity are not wasted. If the price is set equal to the cost of delivering a kWh, consumers who value the kWh more than the cost of delivering it will use the kWh and consumers who value the kWh less will not. This will encourage the development and adoption of energy technologies that are capable of providing the most valuable services to the power grid.

Equity: There should be no unintentional subsidies between consumer types. Note that equity is not the same as social justice, which is related to inequities in socioeconomic status rather than cost. The pursuit of one is not necessarily the pursuit of the other, and vice versa.

Revenue adequacy and stability: Tariffs should recover the authorized revenues of the utility and should promote revenue stability. Theoretically, all tariff designs can be implemented to be revenue neutral within a class, but this would require perfect foresight of the future. Changing technologies and consumer behaviours make load forecasting more difficult and increase the risk of the utility either under-recovering or over-recovering costs when tariffs are not cost reflective.

Bill stability: Consumer bills should be stable and predictable while striking a balance with the other tariff design principles. Tariffs that are not cost reflective will tend to be less stable over time, since both costs and loads are changing over time. For example, if fixed infrastructure costs are spread over a certain number of kWh's in Year 1, and the number of kWh's halves in Year 2, then the price per kWh in Year 2 will double even though there is no change in the underlying infrastructure cost.

Consumer satisfaction: Tariffs should enhance consumer satisfaction. Because most residential consumers devote relatively little time to reading their electric bills, tariffs need to be relatively simple so that consumers can understand them and perhaps respond to the tariffs by modifying their energy use patterns.

ALTERNATIVE DISTRIBUTION TARIFF DESIGNS

Based on the stakeholder interviews described in Section 4 of this report as well as an international survey of domestic tariff reform activity, the following are alternative distribution tariff designs that are being considered around the world. For each alternative tariff design, we summarize major advantages and disadvantages of each relative to the tariff design principles described above. This summary is not exhaustive, but intended to highlight the key points being debated about these tariff designs in other jurisdictions.

The first two tariff design options – demand charges and time-varying unit charges – would require that smart meters be deployed and half hourly settlement be adopted. The other two options – a higher standing charge and "inclining block rates" – would not require new metering or half hourly settlement.[31]

Demand charges

A demand charge is a charge based on a consumer's peak demand over a specified time period – typically the monthly billing cycle. It is typically based on the consumer's maximum demand across all hours of the month, or on their maximum demand during those hours of the month in which network demand as a whole peaks. Since most capital investments on the distribution network are driven by peak demand, the idea is that demand charges will better align the price that consumers pay with the costs that they are imposing on the system.[32]

The primary function of the demand charge is to accurately convey the cost structure of delivering electricity to consumers so that they can make informed decisions about how much

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31 Inclining block rates, also commonly known as rising block tariffs, charge consumers a price that increases with consumption during the billing period. Consumption is assigned to two or more tiers (e.g., the first tier could be the first 100 kWh of a consumer's usage in a month, and the second tier could be all remaining usage in the month), each with its own price. For further discussion is provided later in this section of the report.

32 The question of whether to base the demand measurement on the individual consumer's maximum demand over the month or their maximum demand during peak hours of the day is an important consideration. It depends, in part, on the extent to which customers' individual maximum demands are correlated and driving the local peak on the distribution system.

power to consume, and at what time. There is some evidence that domestic consumers respond to demand charges by smoothing out their electricity consumption profile.[33] When faced with well-designed demand charges, residential consumers may have the incentive to buy smart digital technologies such as thermostats, load controllers, home energy management systems and smart appliances, along with batteries and other storage options.

Demand charges have been used widely in various forms (typically alongside standing and unit charges) in commercial and industrial tariffs for the better part of the last century. In GB, they are a standard feature of the distribution tariff for high voltage consumers. These consumers pay a capacity charge, which "subscribes" them to a pre-specified amount of maximum demand.[34] Demand charges also exist in transmission network charges for large consumers. Referred to as "triads," consumers are charged based on their demand during the three hours of the year with highest demand on the transmission system.

Well-designed demand charges would better align prices with their underlying cost-drivers, and therefore represent an improvement in economic efficiency. This, in turn, leads to an improvement in equity by better recovering costs from the consumers who are imposing those costs on the system. And by providing consumers with an incentive to reduce their bills through demand management, demand charges present an opportunity for consumers to save money. Commonly voiced concerns about demand charges typically relate to understandability. This concern may be addressed through market research that is designed to determine the simple educational messages that best resonate with consumers (e.g., "avoid using many appliances at the same time in order to save money on your bill"). Others have expressed a concern that demand charges may not accurately reflect costs due to the diverse nature of residential loads. A broad range of possible demand charge designs should be considered to address this concern, with a particular focus on aligning the measurement of demand closely with the driver of the costs that it is intended to recover.[35]

Time-varying unit charge

The unit charge can be modified to include time-differentiated prices. Generally, a higher price would be charged during on-peak hours and a lower price charged during off-peak hours, reflecting the corresponding variation in distribution capacity costs by on-peak and off-peak periods. This would improve economic efficiency by better aligning prices with costs. It would provide consumers with an incentive to shift consumption away from higher cost hours, reducing system costs and electricity bills.

Time-varying charges can come in many forms.[36] The most common is a time-of-use (TOU) tariff, with the high peak price and lower off-peak price applying on a predictable, daily basis. In a second form of time-varying pricing, called critical peak pricing (CPP), the peak price would be significantly higher on a limited number of days per year (typically 10 or 15) when the system is

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33 For a summary of these studies, see Ryan Hledik, "Rediscovering Residential Demand Charges," *The Electricity Journal*, August/September 2014.

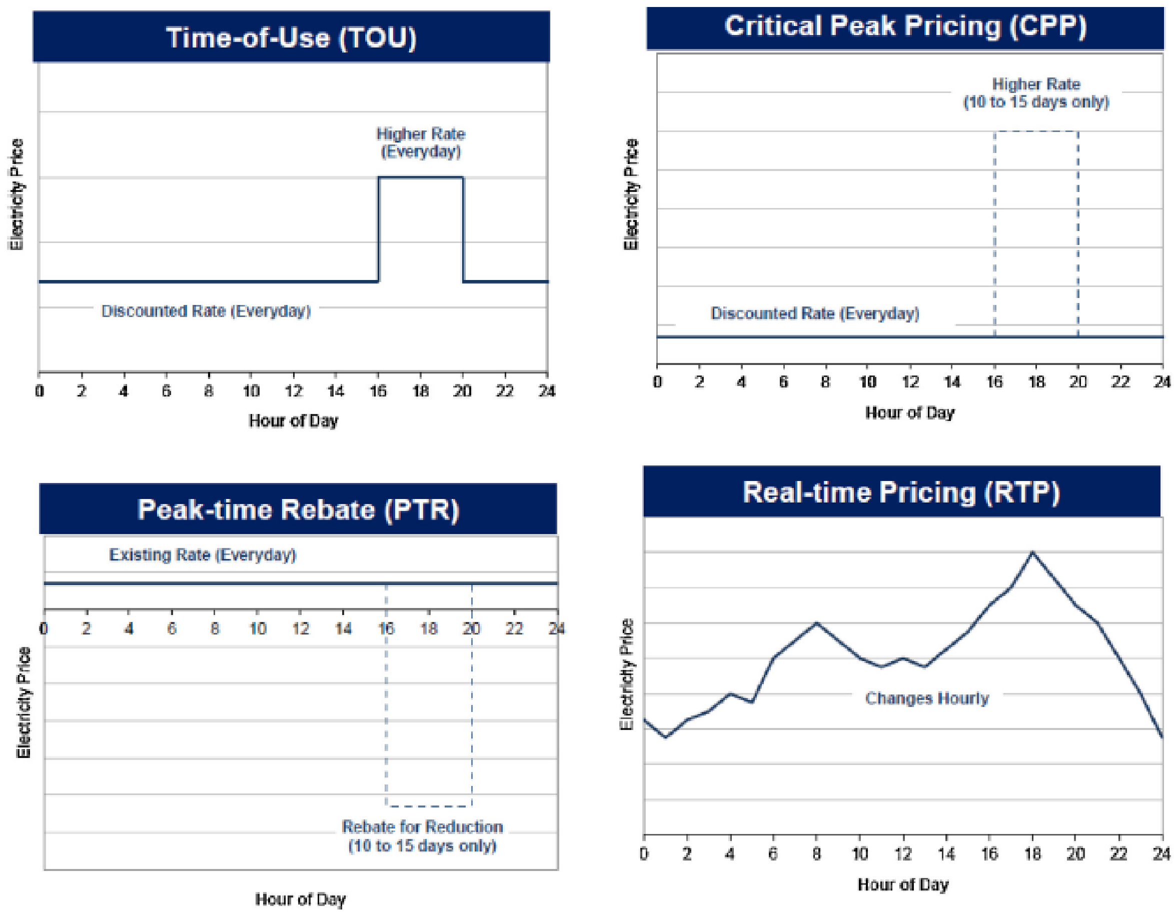
34 Beginning in April 2018, if the consumer's maximum demand exceeds this threshold, they pay a penalty charge that is higher than the capacity charge.

35 For instance, demand could be measured as the customer's demand during the hours of system peak load, or it could be measured during a window of peak hours each day.

36 See Ahmad Faruqui, Ryan Hledik, and Jennifer Palmer "Time-Varying and Dynamic Rate Design," prepared for the Regulatory Assistance Project," July 2012.

most likely to reach its peak, and lower during all other hours of the year.[37] The dynamic nature of a CPP tariff allows the utility to respond with short notice to unexpected reliability- or price-driven events on the system. A third form of time-varying rate, called a peak time rebate (PTR), is in some ways the mirror image of a CPP tariff. It would provide consumers with a payment for reductions in consumption below a predetermined baseline during peak events. A fourth option, real-time pricing (RTP) would provide consumers with an hourly or sub-hourly price. While RTP is typically used to capture hourly variation in energy prices, it could also be applied at the distribution system level to reflect distribution system capacity constraints.[38] Especially as the amount of intermittent generation capacity from wind and solar generating sources increases, distribution system capacity constraints may become less predictable and hence tariff designs that can respond to actual system conditions (such as RTP or CPP) rather than reflect stable patterns (such as TOU) may become more valuable. The various time-varying pricing options are illustrated in Figure 3.

Figure 3: Illustrations of Time-Varying Pricing Tariffs



37 Day-ahead notification of a critical peak pricing event is typically provided.

38 When coupled with locational variation, this is known generally as distribution locational marginal pricing, or DLMP. The concept is beginning to receive attention in the U.S., particularly in New York, where efforts are underway to facilitate the integration of distributed energy resources.

Recently, there has been debate about the appropriate definition of a peak period in a time-varying tariff. Historically, the tariffs have been used to encourage reductions in consumption during peak hours. But with the deployment of renewables, there is an increasing focus on encouraging load building during hours when there may be more generation than demand for electricity. Lower prices during these hours could encourage a shift in consumption that takes advantage of lower energy prices in those hours. This could necessitate a shift in the timing of the peak and off-peak periods, or a tariff with a more dynamic price signal.

Time-varying pricing is perhaps the most commonly explored alternative tariff design in GB. Several pricing pilots in GB have analysed the extent to which domestic consumers will respond to time-varying tariffs.[39] Around 13 per cent of domestic consumers are enrolled in the Economy 7 tariff, which is a time-of-use tariff for consumers with thermal storage.[40] The distribution tariff for commercial and industrial consumers with half hourly settlement includes a "Red-Amber-Green" charging structure, which is a three-period TOU tariff with higher prices during "red hours," lower prices during "amber hours," and even lower prices during "green hours".

The benefits of time-varying unit charges are similar to those of demand charges – they can improve economic efficiency, equity in cost recovery, and provide consumers with an opportunity for bill savings. There is some concern in the industry that domestic consumers will not understand these tariff designs, though that concern is being alleviated through the consistent findings in pricing pilots that consumers respond to the new price signals.[41] Another concern is that, while time-varying unit charges are a good way to recover variable costs, they are not the most appropriate charge for recovering demand-driven capacity costs. Stakeholders with this concern suggest that they should be coupled with a demand charge to better reflect the underlying cost-structure.

Higher standing charge

Most domestic tariffs currently offered around the world include a modest standing charge (sometimes called a consumer charge, a consumer service charge, or a monthly service charge). While the size of the standing charge is generally consistent with the magnitude of fixed consumer costs like metering and billing, it typically does not account for the costs of distribution capacity. Proposals to increase the standing charge have become increasingly common – a recent

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39 See "DNO Guide to Future Smart Management of Distribution Networks Summary Report," *UK Power Networks & Low Carbon London Learning Lab*, December 2014. See also "Demand Side Response in the domestic sector – a literature review of major trials: final report," *Frontier Economics and Sustainability First*, August 2012. See also "Energy Demand Research Project: Final Analysis," *AECOM*, June 2011. See also "Insight Report: Domestic Time of Use Tariff: a comparison of the time of use tariff trial of the baseline domestic profiles," Gavin Whitaker, Robin Wardle, Christian Barteczko-Hibbert, Peter Matthews, Harriet Bulkeley, Gareth Powells, *Customer-Led Network Revolution*, 23 January 2013.

40 Citizens Advice, "Take a Walk on the Demand-Side," August 2014. https://www.citizensadvice.org.uk/about-us/policy/policy-research-topics/energy-policy-research-and-consultation-responses/energy-policy-research/take-a-walk-on-the-demand-side/

41 A survey of more than 40 time-varying pricing pilots has found that consumers responded to price signals in the vast majority of cases. See the discussion in Section 7 for more information.

survey found that there are open proposals to increase the standing charge in a utility's domestic tariff in at least 18 of the 50 states in the U.S.[42]

A variation on a higher fixed monthly charge is a minimum bill. The minimum bill ensures that all consumers will pay a minimum threshold amount each month. For instance, with a minimum bill of £20/month, a consumer whose bill would have been £15 under the existing tariff for a given month would be billed £20 for that month. In a different month, if the consumer's bill under the existing tariff would be £40, then the minimum bill feature would not be relevant and their bill would remain unchanged. The theory is that the minimum bill amount can be associated with the average consumer's cost of using the grid and therefore guarantee that amount to be recovered on a monthly basis.

As has been discussed throughout this report, distribution tariffs in GB have included a standing charge for decades. Currently, around 20 per cent of distribution revenue is collected through the standing charge, with the remaining 80 per cent is recovered through the unit charge.

A higher standing charge will increase stability and predictability of consumer bills to some degree (assuming the structure is passed on to consumers by suppliers). Standing charges are also simple and easy for consumers to understand, as they are already a feature of most consumers' electricity bills. An argument in support of increasing standing charges is that they better reflect the fixed nature of distribution system costs in the short run. By ensuring that a portion of the cost of the grid will be collected from each consumer regardless of their consumption level, standing charges can help to alleviate the challenges associated with under-collection of costs from solar PV consumers described in Section 3 of this report.

A common criticism of standing charges is that they are a "blunt instrument" that bills each consumer the same regardless of their actual use of the distribution system. Fixed charges do not offer the pricing signal to reduce peak demand that is accomplished with demand charges or time-varying unit charges. Similarly, some have argued that an increased standing charge, coupled with a reduction in the unit charge, will reduce the incentive to invest in energy efficiency measures and could contradict energy policy goals.[43]

Inclining block rate

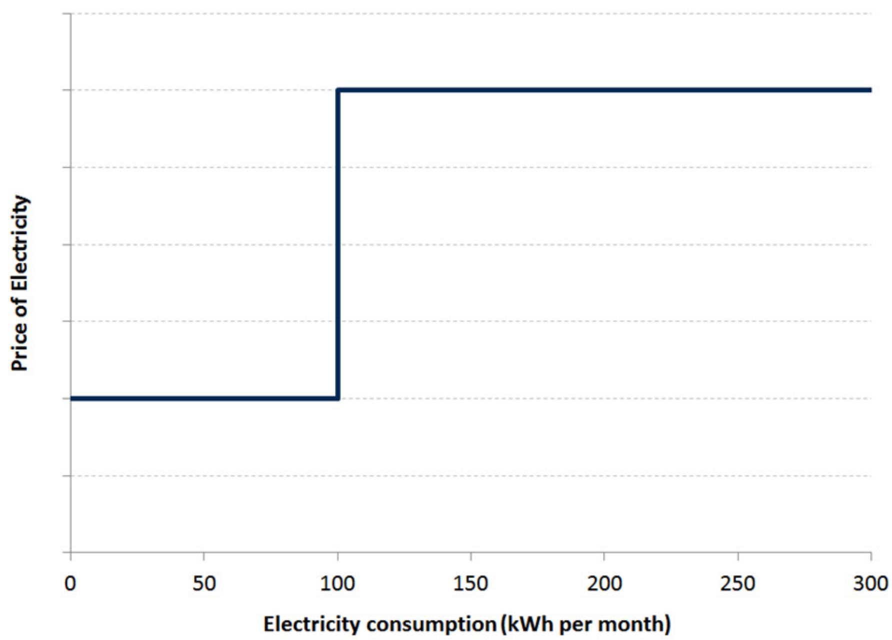
Inclining block rates (IBRs), also commonly known as rising block tariffs, charge consumers a price that escalates with consumption over the course of each billing period. Often, IBRs are designed to charge a lower than average price for a minimal amount of electricity consumption that is deemed necessary for basic services like lighting and refrigeration, and a higher price for consumption associated with "discretionary" electricity consumption. For example, an inclining block rate in a domestic distribution charge could include a price of 1 p/kWh for the first 100 kWh of consumption in a month and 3 p/kWh for all remaining consumption in the month. IBRs are not necessarily limited to two tiers. The domestic tariff in Saudi Arabia, for example, recently

[42] Inskeep, Benjamin, et al. "The 50 States of Solar," prepared by the NC Clean Energy Technology Center and Meister Consultants Group," Q3 2015. https://nccleantech.ncsu.edu/wp-content/uploads/50-States-of-Solar-Q3-FINAL_25.pdf

[43] For instance, in response to a recent proposal by utilities in California to introduce a $10/month standing charge, environmental advocacy groups such as the Natural Resources Defense Council and the Sierra Club intervened and argued that this would reduce the portion of a consumer's bill that can be avoided through conservation and investments in energy efficient technologies and on-site solar.

included as many as eight price tiers.[44] An illustration of a hypothetical IBR is provided in Figure 4.

Figure 4: Illustration of an Inclining Block Rate



A common challenge in designing IBRs is determining how to set the price of each tier. There is not a clear, direct cost-basis for the tariff's design, as the cost of running the power system does not increase with consumption over the course of the billing period. One approach to setting the prices is to base the price in the final tier on peak marginal costs, and set the first tier price to maintain revenue neutrality. Alternatively, prices may be established in some cases to promote certain policy goals, such as achieving a target level of energy savings or imposing rate increases only on larger domestic users.

While IBRs are common tariff designs (a survey of U.S. utilities determined that one in three offered an IBR), they are a less common application in distribution tariffs.[45] This is most likely due to a lack of clear relationship between the structure of an IBR and distribution system costs. We are not aware of the use of IBRs in distribution tariffs in GB, though the stakeholder interviews described in Section 4 did suggest that some suppliers have offered tiered tariff designs. Regardless, given a general policy focus on energy efficiency and the prevalence of IBRs in tariffs in other regions, they are considered in this study.

IBRs are commonly introduced to promote conservation, though the specific decisions that determine the design of an IBR play an important role in this regard. For instance, one study found that an IBR could potentially induce an increase in consumption if a majority of consumption is exposed only to the lower priced tiers.[46]

44 ECRA website: http://www.ecra.gov.sa/en-us/ECRARegulations/ElectricityTariff/Pages/Tariffconsumption.aspx

45 BC Hydro, "2008 Residential Inclining Block Rate Application," Vancouver, B.C., February 2008.

46 Ahmad Faruqui, Ryan Hledik, and Wade Davis, "The Paradox of Inclining Block Rates," *Public Utilities Fortnightly*, April 2015.

IBRs also are a relatively easy concept for consumers to understand (i.e., the more you use, the higher the price you pay). They have been favoured by groups with an interest in reducing electricity bills for small domestic consumers. Their beneficial impact on the bills of small consumers is discussed further in Section 8.

A common disadvantage of IBRs is that there is not a clear relationship between the pricing structure and underlying costs. In other words, electricity costs do not rise with consumption over the course of the billing period, even though this is the structure of the tariff. This misalignment of prices and costs can lead to uneconomic electricity consumption decisions and unintended cross-subsidies within a consumer class. For instance, artificially high priced outer tiers of an IBR could encourage consumers to install energy efficiency measures or DG in order to avoid the higher price, when in fact the costs of those measures are not outweighed by avoided costs on the system.

IBRs also have the potential to increase bill volatility. During an unexpectedly cold winter, for instance, when consumers use more electric heat than normal, they could end up using electricity in higher priced tiers, leading to significant and unexpected bill increases in those months. Another common concern about IBRs is that they could penalize large families, with many people living in the same home, or consumers with electric heat who do not have access to a reasonable alternative.

OTHER DISTRIBUTION TARIFF CONSIDERATIONS

In addition to the design of the tariff, there are also important considerations about how it is deployed to consumers.

Locational variation in charges

Some tariff analysts and distribution system planners have begun to consider the possibility of distribution charges that vary depending on a consumer's location *within* the distribution system.[47] The notion of a distribution locational marginal price (DLMP) has begun to garner attention in jurisdictions that are confronting the issue of how to integrate high levels of distributed energy resources into the distribution system. It could potentially contribute significant economic efficiency benefits by encouraging load reductions or the installation of DG in locations of the distribution system where it is most beneficial.

Taken to its extreme, the DLMP approach could require that billions of location-specific prices be computed in a given market on a monthly basis.[48] However, there are options for simplifying this pricing model. For instance, Con Edison, the distribution utility that serves consumers in New York City, offers a demand-side response program that offers two different incentive payments depending on where consumers are located on the distribution system.[49] Consumers located in

47 See, for instance, Devi Glick, Matt Lehrman, and Owen Smith, "Rate Design for the Distribution Edge," Rocky Mountain Institute, August 2014. The paper discusses the potential benefits of unbundling rates across various attributes and introducing temporal and spatial granularity into the tariff's design.

48 Paul De Martini and Lorenzo Kristov, Distribution Systems in a High Distributed Energy Resources Future, prepared for Lawrence Berkeley National Laboratory, October 2015. https://emp.lbl.gov/sites/all/files/FEUR_2%20distribution%20systems%2020151023.pdfhttps://emp.lbl.gov/sites/all/files/FEUR_2%20distribution%20systems%2020151023.pdf

49 Con Edison website: http://www.coned.com/energyefficiency/demand_response_program_details.asp

parts of the distribution system with capacity constraints are offered the higher of the two incentive payments for participating.

Aside from technical challenges, a common concern about even simple forms of locational pricing is the perception among consumers that they are being discriminated against. For instance, a consumer may wonder why he or she is paying a higher price than a neighbour for what is perceived to be the same product, without fully understanding the differences in costs across locations on the system.

Voluntary or mandatory

With any new tariff offering, a key consideration is whether participation should be mandatory. If participation is voluntary, a decision must be made as to whether to offer it on an opt-out basis (where consumers are automatically enrolled in the tariff with the option to revert to a different tariff option) or an opt-in basis (where consumers must proactively sign up for the new tariff in order to enrol). Opt-out tariff offerings have been shown to achieve significantly higher enrolment levels than opt-in offerings.[50]

In the context of the GB market structure, where consumers are on either the Unrestricted or Two Rate tariff, the question would be whether an alternative tariff design would be introduced as a third option, or if the consumers on the Unrestricted tariff (representing roughly 80 per cent of the population) would be automatically enrolled in the new tariff.

DG-specific or offered to all consumers

Given that interest in distribution tariff reform is driven to a significant extent by growth in adoption of DG, a key question is whether the new tariff should apply only to consumers with DG or all residential consumers. Modifying the tariff only for DG consumers has the advantage of restricting the immediate bill impacts of the tariff change to a small subset of the utility's consumers. Since DG consumers have a different net load profile than other consumers and are acting both as consumers and as generators, their unique status has been deemed by some to warrant the creation of a specific consumer class.[51] Offering special tariffs to DG consumers is analogous to the development of "standby tariffs" for "partial requirements customers," a common practice in some jurisdictions for commercial and industrial consumers. In addition to the tariff designs described previously, DG-specific charges could be levied based on the size of the installed DG capacity, the output of the facility, or a one-time connection fee.

In some jurisdictions where DG-specific tariffs have been created, rooftop solar developers have filed lawsuits on the basis that DG consumers are being discriminated against.[52] Alternatively, if the proposed tariff changes are cost-based and represent an overall improvement upon the existing tariff structure according to sound principles of tariff design, then it could be argued that

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50 Ahmad Faruqui, Ryan Hledik, and Neil Lessem, "Smart by Default," *Public Utilities Fortnightly*, August 2014.

51 A net load profile is the customer's load shape after production from on-site generation has been subtracted from it.

52 For example, SolarCity filed a lawsuit in Arizona against Salt River Project for introducing a rate specifically to more fully recover costs from residential consumers with distributed generation. http://www.greentechmedia.com/articles/read/arizona-court-advances-solarcity-lawsuit-against-salt-river-projecthttp://www.greentechmedia.com/articles/read/arizona-court-advances-solarcity-lawsuit-against-salt-river-project

only making these changes for DG consumers is a missed opportunity to improve the tariff design of the entire domestic class.

Exemptions for existing consumers

Typically, significant changes to the DG tariff have been accompanied by a rule that allows existing DG consumers to continue to be billed under the old pricing policy. The argument for this approach is that those consumers made the decision to purchase their DG systems under a pre-established pricing agreement with the utility – or at least with the expectation that the existing arrangement would continue to be honoured in the future. The policy avoids placing an unexpected financial burden on those consumers under the new pricing structure. The counterargument to such a policy is that all investments are subject to the risk that future policies can change, and that DG investments are no different in this regard and should therefore not be given any special treatment.

Section 6: International case studies

Section 6 highlights:

- Domestic tariff reform activities are particularly concentrated in areas of North America and Australia with significant deployments of smart meters and/or rooftop solar
- Ontario (Canada) demonstrates issues associated with the rollout of TOU rates on a default basis in a region with retail competition
- Arizona (USA) illustrates different uses of demand charges to address concerns about equity in cost recovery in an environment of growing rooftop PV adoption
- California (USA) provides an example of how competing policy objectives can lead to a range of rate reform initiatives, including TOU, IBR, and standing charge proposals
- Victoria (Australia) highlights the tariff design experience of distribution utilities in a region with high rooftop PV adoption and fully-deployed smart meters

Introduction

The alternative tariff design options described in Section 5 have been implemented or proposed in various jurisdictions around the world. In North America and Australia there has been a particularly high degree of domestic tariff reform activity, driven generally by growth in DG, the deployment of smart meters, and generous compensation policies for rooftop solar PV. The following are case studies highlighting this activity. In most cases, tariff reform extends beyond the distribution portion of the tariff to include generation and transmission as well. Similarly, in some cases the distribution function is part of a larger regulated, vertically-integrated utility. However, the basic concepts and tariff design considerations are largely the same. These case studies are provided to illustrate real world experience with various tariff designs. They are not a comprehensive assessment. The experience of any given region will vary due to differences in market structure, regulatory environment, and consumer base, among other factors.

Ontario, Canada

Background

Unlike its neighbouring provinces in Canada, Ontario does not have a hydro-dominated power supply, making variation in the hourly prices of the Ontario energy market more pronounced. Further, with the expected increase in market penetration of renewable resources due to Ontario's energy policy directives, price volatility and peak energy costs are expected to increase in the future. These factors, combined with a longer-term need to slow the growth in peak demand and thereby avoid investing in expensive new peaking capacity, make TOU pricing a logical choice for the retail electricity tariff in Ontario. As such, provincial policy established TOU pricing as the mandatory tariff structure for all consumers receiving default supply in the province.

The Ontario case study is relevant because it highlights issues in transitioning to a time-varying tariff on a mandatory basis. The tariffs were rolled out with smart meters, to take advantage of the new digital metering capability. Other than Italy, Ontario is the only region in the world with mandatory TOU tariffs for domestic consumers.

Tariff reform activity

As part of TOU implementation, each of the 76 utilities in Ontario is accountable for:

- Undertaking the installation of smart meters for all domestic consumers and general service consumers under 50 kW

- Enrolling smart meters in the centralized provincial Meter Data Management Repository ("MDM/R")
- Activating TOU pricing across its service territory

Utility progress on TOU implementation was monitored by mandated monthly reporting obligations. As of the date that this mandatory reporting requirement ended in 2012, 99 per cent of the RPP eligible consumers had their smart meters installed; 92 percent were enrolled with MDM/R, and 89% were on TOU billing.[53]

TOU prices are set by the regulator (the Ontario Energy Board, or OEB) and reviewed bi-annually in May and November. The OEB price review is based on an analysis of electricity supply cost forecasts for the year ahead and a true-up between the price paid by consumers and the actual cost of generation in the previous billing period. Consumers may be exempted from TOU pricing by executing a fixed-price contract with an electricity retailer for a term generally between three to five years.

Ontario's TOU consists of three pricing periods.[54] The prices vary seasonally and may be adjusted by the OEB every six months to reflect changes in system conditions and market prices. Only the commodity (generation) prices are time varying. Other prices that do not vary by time of day include distribution costs, network charges, connection charges, and costs of the province's feed-in-tariff program, among others. The non-time-varying portion of the electricity tariff in Ontario has been considered a problem by some, because it has diluted the peak-to-off-peak price ratio of the all-in tariff. On an all-in basis, the typical TOU tariff in Ontario has an all-in peak-to-off-peak price ratio of 1.5-to-1.[55] This modest price ratio can limit the incentive that consumers have to shift consumption away from peak hours. Some stakeholders have argued that certain costs should be recovered only during peak hours, rather than being spread over all hours, in order to amplify the price ratio and better reflect the peak-related nature of those costs.

While Ontario's tariff applies to the commodity portion of the bill, it is an example of an effective default TOU tariff option in a market with retail competition. In spite of the mild price ratio and the default nature of the tariff's deployment, analysis of Ontario utility consumer load data has found that consumers have shifted load away from the higher priced peak hours. On average, domestic consumers are estimated to have reduced their peak period consumption by around two percent.[56]

An important issue was encountered during the rollout of the TOU tariff. Due to the geographical nature of the rollout, the first consumers enrolled in the tariff tended to be those who would experience a bill increase under the new design. The result, predictably, was consumer backlash and a perception that TOU pricing would increase bills for all consumers. Eventually, through outreach and consumer education this perception issue was addressed.

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[53] OEB website: http://www.ontarioenergyboard.ca/OEB/Industry/Regulatory+Proceedings/Policy+Initiatives+and+Consultations/Smart+Metering+Initiative+(SMI)/Smart+Meter+Deployment+Reporting

[54] OEB website: http://www.ontarioenergyboard.ca/OEB/Consumers/Electricity/Smart+Meters/FAQ+-+Time+of+Use+Prices

[55] OEB website: http://www.ontarioenergyboard.ca/OEB/Consumers/Electricity/Electricity+Prices

[56] "Year Two Analysis of Ontario's Full Scale Roll-out of TOU Rates," Ahmad Faruqui, Neil Lessem, and Sanem Sergici, *The Brattle Group*, 16 December 2014.

Relevance to GB

The Ontario case study is relevant to GB because it highlights the impacts of a province-wide change in the domestic tariff structure in a market with retail competition, all of which was enabled by a smart metering rollout. One critical lesson learned from this experience is the importance of deploying new tariffs in a way that will provide consumers with an opportunity to grow accustomed to their new tariff structure over time. While it is difficult to anticipate all of the potential issues associated with a full-scale tariff rollout, building in a gradual transition will dampen the impact of any unforeseen problems early in the process.

Ontario provides a good example of the benefits of regularly evaluating the impacts of the new tariff structure. The Ontario Power Authority has empirically evaluated consumer response to the new TOU rate for each of the three years since its deployment. These evaluations have produced not only meaningful estimates of the magnitude of the peak reductions – which translate into avoided system costs and lower bills for consumers – but also provide information that can be used to refine the tariff design going forward. In GB, establishing such an evaluation plan before rolling out a new tariff design would be a prudent activity.

ARIZONA, UNITED STATES

Background

Arizona has a hot, sunny desert climate where the high temperature can exceed 37 degrees Celsius more than 100 days per year. It has some of the highest solar energy potential in the U.S.[57] The average retail rate in the state is slightly higher than the national average, making it an attractive market for rooftop solar developers in recent years. Net photovoltaic generation in Arizona grew 25.6% between December 2014 and December 2015.[58] Perhaps unsurprisingly, this rapid change has led utilities in the state to propose alternative tariffs for consumers with DG.

Arizona is an interesting case study, because it highlights utility proposals to offer demand charges in response to the growth in adoption of rooftop PV. Interest in demand charges for domestic consumers is a relatively recent phenomenon in the U.S., though Arizona Public Service has more of its domestic consumers enrolled in a tariff with a demand charge than any other utility (around 10 per cent). The case studies highlight both similarities and differences the utilities in the state have taken in addressing this issue. All utilities in Arizona are vertically integrated, without retail competition, but the key drivers for reforming tariffs, and the alternative tariff designs being considered, are relevant to future tariff design activities in GB.

Tariff Reform Activity

In February 2015, the Salt River Project ("SRP") Board of Directors approved the E-27 tariff, also known as the Customer Generation Price Plan for Residential Service.[59] The E-27 tariff is a

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57 For a graphical representation of solar potential by state, see: http://energy.gov/maps/solar-energy-potentialhttp://energy.gov/maps/solar-energy-potential

58 "Electric Power Monthly: Data for December 2015," *United States Energy Information Administration*, February 26, 2016, Table 1.17.A "Net Generation from Solar Photovoltaic."

59 Scott Harelson, "SRP Board Approves Reduced Price Increases," Salt River Project press release, 26 February 2015, accessed on 1 July 2015, http://www.srpnet.com/newsroom/releases/022615.aspxhttp://www.srpnet.com/newsroom/releases/022615.aspx.

three-part tariff with a standing charge, a unit charge, and a demand charge. The tariff only applies to residential consumers who install distributed generation ("DG").[60] SRP is a not-for-profit [right??] public utility that is regulated by a board of directors elected by landowners.

In the E-27 tariff, the standing charge varies with the size of the consumer's connection, and ranges from $32.44/month to $45.44/month, both of which higher than the $20 monthly standing charge in the tariff for non-DG consumers. The demand charge is structured as an increasing block rate and varies by season. In the peak summer months of July and August, it ranges from $9.59/kW-month for a consumer's first 3 kW of demand, to $17.82/kW-month for the next 7 kW of demand, to $34.19/kW-month for demand in excess of 10 kW.[61] Consumers who installed DG or had a contract submitted to SRP on or prior to December 8, 2014 are grandfathered on to their pre-existing price plans. A summary of the E-27 tariff is provided in Table 1.

Table 1: Summary of Salt River Project's "Customer Generation Price Plan"

	Summer Peak Season		Summer Season		Winter Season	
	On Peak	Off Peak	On Peak	Off Peak	On Peak	Off Peak
Demand charge - first 3 kW ($/kW)	9.59	0	8.03	0	3.41	0
Demand charge - next 7 kW ($/kW)	17.82	0	14.63	0	5.46	0
Demand charge - all add'l kW ($/kW)	34.19	0	27.77	0	9.37	0
Volumetric charge ($/kWh)	0.0486	0.0371	0.0633	0.0423	0.0430	0.0390
Customer charge ($/month)	32.44					

Source: SRP Website. http://www.srpnet.com/prices/priceprocess/pdfx/TempNov2015RatebookPUBLISHED.pdf

In July 2013, Arizona Public Service ("APS") proposed a new solar compensation policy for consumers with DG. APS proposed two tariff options: the first option would put consumers with DG on a three-part tariff with a demand charge and compensate them for the output of their rooftop PV systems at the full retail tariff. The second option was a "buy-sell arrangement" under which consumers with DG would have all consumption billed under one of the existing tariff options, but they would be paid a lower wholesale energy price for the total amount of electricity that they generate. Both options were designed to better recover network costs from consumers with DG.

In November 2013, the state energy regulator, the Arizona Corporation Commission ("ACC") voted instead to implement an alternative proposal. The ACC's decision imposed a $0.70/kW grid access charge on installed solar PV capacity, equating to a surcharge of roughly $5/month for a typical domestic rooftop solar installation.[62] In April 2015, APS requested an increase from

60 Ahmad Faruqui and Ryan Hledik, "An Evaluation of SRP's Electric Rate Proposal for Residential Customers with Distributed Generation," prepared for Salt River Project, January 2015, p.14, accessed 3 February 2016, http://www.srpnet.com/prices/priceprocess/pdfx/DGRateReview.pdfhttp://www.srpnet.com/prices/priceprocess/pdfx/DGRateReview.pdf.

61 "SRP Standard Electric Price Plans: Salt River Project Agricultural Improvement and Power District, Temporary Prices Effective November 2015 – April 2016 Billing Cycle," Salt River Project, 6 October 2015, pp. 29-30, accessed 3 February 2016, http://www.srpnet.com/prices/priceprocess/pdfx/April2015RatebookPUBLISHED.pdf.http://www.srpnet.com/prices/priceprocess/pdfx/April2015RatebookPUBLISHED.pdf.

62 "APS's Proposal to Change Net-Metering," ASU Energy Policy Innovation Council, updated December 2013, pp. 2, 3, and 5, accessed 1 February 2016, https://energypolicy.asu.edu/wp-content/uploads/2013/12/APS-Net-Metering-Brief-Sheet-Draft-_-Final_updated-Dec-

$0.70/kW to $3.00/kW.[63] In response to opposition from solar developers, APS subsequently offered to withdraw the proposed grid access charge in favour of opening a modified hearing that would exclusively address the cost of serving solar and non-solar consumers, as well as the structure of how those costs would be collected. On October 20, 2015, the ACC ordered APS's cost of service issues to be included in a generic docket on the value of distributed energy and ordered the utility to file a rate case no later than June 30, 2016.[64]

UNS Energy Corporation, the parent company of two utilities in Arizona, asked the ACC to approve a mandatory three-part tariff with a demand charge for consumers with DG who submit connections for new DG facilities after June 1, 2015. While this three-part tariff would be optional for standard residential consumers, UNS is also proposing an increased standing charge for all residential consumers that would be set at $20/month, an increase from the current $10/month.[65] Additionally, the utility is proposing to purchase excess energy from new rooftop systems using the Renewable Credit Rate, which would be set to the market price for power generated by grid-scale solar arrays, which is lower than the retail tariff.[66]

Relevance to GB

In some ways, Arizona and GB are significantly different. Arizona's hot climate and vertically integrated utilities are the two most relevant differences. However, in spite of these differences, the experience in Arizona highlights a number of useful lessons for GB.

First, APS's experience with demand charges suggests that this tariff design option can be attractive to consumers, in contrast to some concerns that consumers may not understand or want demand charges. While APS's enrolment rate of 10 per cent may appear low on the surface, it is a significant take rate for a voluntary, opt-in tariff offering. APS also notes that consumers have reduced their demand after enrolling in the tariff option, providing some evidence that consumers are able to respond to the tariff design.

Like Arizona, GB is experiencing rapid growth in PV adoption. In anticipation of further growth, the diversity in response of Arizona's utilities highlights an important decision that GB may eventually need to face. Specifically, some utilities have proposed changing the tariff structure only for consumers with rooftop PV, whereas APS has proposed to change the tariff structure for all consumers. Solar developers have strongly contested a tariff change only for PV consumers

2013.pdfhttps://energypolicy.asu.edu/wp-content/uploads/2013/12/APS-Net-Metering-Brief-Sheet-Draft-_-Final_updated-Dec-2013.pdf.

63 "APS Asks to Reset Grid Access Charge for Future Solar Customers," APS press release, 2 April 2015, accessed on 20 July 2015, https://www.aps.com/en/ourcompany/news/latestnews/Pages/aps-asks-to-reset-grid-access-charge-for-future-solar-customers.aspxhttps://www.aps.com/en/ourcompany/news/latestnews/Pages/aps-asks-to-reset-grid-access-charge-for-future-solar-customers.aspx.

64 Arizona Corporation Commission, *Order Rescinding Decision No. 75251, Dismissing APS's Motion to Reset and Closing Docket No. E-01345A-13-0248*, Docket No. E-01345A-13-0248, 27 October 2015.

65 "Unisource Energy Service Seeks Approval of New Electric Rates to Better Reflect Customers' Use of its Upgraded Utility System," UniSource Energy Services press release, 5 May 2015, accessed on 10 July 2015, https://www.uesaz.com/news/newsroom/release/index.php?idRec=342https://www.uesaz.com/news/newsroom/release/index.php?idRec=342.

66 Arizona Corporation Commission, *Application*, Docket No. E-04204A-15-0142, 5 May 2015, pp. 8-9, https://www.uesaz.com/doc/UNSE_Rate_Application.pdfhttps://www.uesaz.com/doc/UNSE_Rate_Application.pdf.

and have, in some cases, ceased operations in states. While pro-solar environmental groups have also opposed this type of isolated tariff change, it has not been met with particularly strong resistance by consumer advocacy groups who may be concerned about the shifting of costs to lower income consumers who do not have PV. Regulatory staff, however, have pushed for an approach like that proposed by APS, arguing that the new tariff structure will benefit all consumers. Utilities are generally quite divided on which of these two approaches to take.

California, United States

Background

California has been a centre for residential tariff reform activity for several years. The smart metering business cases for the state's three investor-owned utilities depended in part on the benefits that time-varying tariffs would bring to the power system. As such, there has been long-standing interest and debate in the state about how best to deploy these tariffs to consumers. Additionally, like Arizona, California is a state with high solar PV potential. California leads the U.S. in total installed solar capacity and has been the focus of many solar developers in part because of generous solar-friendly policies but also because of the sheer size of the potential market.

The California case study highlights a broad range of issues relevant to distribution tariff design, including the design of tariffs with an IBR structure, the implementation of TOU tariffs on a default basis, and the tension of moving to cost-reflective tariffs while also promoting clean energy policies.

Tariff reform activity

The California utilities have an IBR tariff structure for their residential consumers. While the tariff was initially only two tiers with a modest price differential (1.15-to-1 for Pacific Gas & Electric in 2001), a number of factors caused the number of tiers to increase and the differential to grow over time.[67] At one point in 2010, PG&E had an IBR with five tiers, with a first tier price of 11.9 cents/kWh and a fifth tier price that reached 49.8 cents/kWh (a price differential of 4.2-to-1).[68] There was no cost basis for this design. Among a number of challenges that this tariff design posed, it was perceived to be leading to uneconomic adoption of rooftop PV from a system cost perspective. Consumers were installing solar PV systems sized just to avoid the highest priced tiers. And the panels were often installed facing south, which maximizes total electrical output but has less value than when the panels face west and generate electricity during peak times.[69] To address this issue, the utilities reduced the number of tiers in the IBR to two through a series of rate cases and decreased the price differential as well (PG&E's price differential is now 2-to-1).[70]

There has also been a significant focus in California on electricity pricing specifically for DG consumers. In October 2013, state legislation was passed in California, directing the state energy regulator (the California Public Utility Commission, or "CPUC") to reform residential tariffs by

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67 PG&E website: http://www.pge.com/tariffs/electric.shtml#RESELEC

68 Ibid.

69 This particular issue of south-facing PV panels is not just specific to California and is a common problem with non-time-varying compensation for PV customers in the northern hemisphere.

70 The new IBR design includes a surcharge for "super users" who consume more than four times their allotted "baseline quantity."

December 31, 2015.[71] This state legislation requires a new framework for analysing the benefits and costs of DG for the grid and for the public.

On January 28, 2016, the CPUC voted 3 to 2 approving a new DG tariff.[72] In this decision, the Commission declined to "impose any demand charges, grid access charges, installed capacity fees, standby fees, or similar fixed charges on… residential consumers [with DG] while the CPUC is working on how, if at all, any such fees should be developed for residential consumers."[73] The decision upholds the current retail tariff for consumers with DG, preserving the basic features of the existing tariff. In reference to the utilities' tariff proposals, the CPUC commented, "The differing methods of analysis and proposed charges strongly suggest that more work is needed before any major shifts in the paradigm for the… successor tariff are implemented."[74]

However, the CPUC did accept three notable changes to the existing tariff for DG consumers, specifically related to Time-of-Use ("TOU") tariffs, non-bypassable charges, and interconnection fees. With respect to TOU tariffs, the CPUC explained, "participation in available TOU tariffs can be an effective way to align the incentives of consumers on the… successor tariff with the system needs."[75] As a result, the new policy for DG consumers requires that all participating consumers be on a mandatory TOU tariff. TOU tariffs for residential consumers are anticipated to be in place by 2019.[76]

The CPUC also changed its treatment of "non-bypassable" charges that DG consumers are required to pay. Under the original tariff, certain charges such as nuclear decommissioning costs, were deemed "non-bypassable". These costs were recovered from DG consumers on the basis of their net consumption. Under the new DG pricing policy, consumers pay non-bypassable charges on the full amount of electricity delivered from the grid, rather than net consumption.[77]

Lastly, the CPUC agreed with the utilities' proposals to institute a one-time interconnection fee (connection fee) that will "allow the utility to recover the costs of providing the interconnection service from the consumer benefitting from the interconnection." Based on the utilities' proposals, this fee is estimated to range from $75 to $150 depending on the utility.[78]

Relevance to GB

Like GB, the business case for smart meters in California was based in part on the benefits of new programmes that would be enabled by the smart metering infrastructure. As such, the state is now

71 California State Assembly, *Assembly Bill No. 327*, 7 October 2013, pp. 91-92, http://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201320140AB327.

72 Public Utilities Commission of the State of California, *Decision Adopting Successor to Net Energy Metering Tariff*, Rulemaking 14-07-02, 28 January 2016.

73 Ibid, p. 2.

74 Ibid, p. 75.

75 Ibid, p. 76.

76 Ibid, p. 92.

77 Non-bypassable charges include Public Purpose Program Charge, Nuclear Decommissioning Charge, Competition Transition Charge, and Department of Water Resources bond charges; Ibid, pp. 89-90.

78 Jeff St. John, "California Net Metering 2.0 Keeps Retail Rates for Rooftop Solar," Greentech Media, 15 December 2015, accessed 5 February 2016, http://www.greentechmedia.com/articles/read/breaking-california-net-metering-2.0-keeps-retail-rates-for-rooftop-solarhttp://www.greentechmedia.com/articles/read/breaking-california-net-metering-2.0-keeps-retail-rates-for-rooftop-solar.

committed to rolling out default time-of-use rates to all consumers to encourage economically beneficial load shifting. Prior to the full-scale rollout, however, a comprehensive pricing pilot will be conducted to determine the features of the tariff design that work best for consumers. As GB moves forward with its smart metering deployment, similar full-scale, country-wide pilots may be useful to determine the most effective ways to convey time-varying pricing to consumers. This could be done through partnerships between DNOs and suppliers.

The California experience also highlights how an emphasis on environmental policy can shape tariff design. The California utilities, for example, do not have a standing charge in spite of the fact that some of the utility's costs, such as metering and billing, are fixed on a per-consumer basis. Proposals to introduce a standing charge are met with stiff resistance by environmental groups due to concerns that this will disincentivise investments in energy efficiency and solar PV. Proposals to reduce the price differential in the IBR, while having achieved some recent traction, are resisted for similar reasons. Ultimately, GB's strong focus on decarbonization may lead to similar considerations. This highlights the tension in developing a tariff that is economically efficient and cost-based while simultaneously promoting other potentially contradictory policy objectives.

VICTORIA, AUSTRALIA

Background

Australia's dry climate and latitude give it a high potential for solar energy production. The country ranks among the top ten worldwide for installed PV capacity. Like GB, the Australian market has been deregulated, with retail competition. In 2009 smart meters were implemented by mandate across the state of Victoria.[79] Victoria is currently the only province in Australia with fully deployed smart meters.[80]

Tariff reform activity

In concert with the smart metering rollout, distribution utilities began to offer time-varying retail tariff structures. In 2010, for instance, AusNet introduced a critical peak pricing tariff to incentivize businesses to decrease demand on five days of high network demand during the summer. The tariff contributed to an annual peak demand reduction of 2.5% across AusNet's electricity distribution network.[81]

In spite of the momentum toward time-varying pricing in Victoria, concerns regarding the impact of TOU tariffs on consumers led the Victorian government to put a hold on tariff reform activities in March 2010.[82] Concerns were primarily related to impacts on vulnerable groups such as the elderly, long-term unemployed, low-income households, and people with disabilities who might be most negatively impacted by the new pricing plan.[83] The moratorium was lifted in September

79 Tony Wood, "Victoria goes slow on electricity tariff reform," *Australian Financial Review*, 4 February 2016.

80 Energy Networks Association, "Towards a national approach to electricity network tariff reform," December 2014, 10.

81 "Electricity Distribution Network: Demand Side Engagement Strategy," *SP AusNet*, 29 August 2013, 7.

82 "Towards a national approach to electricity network tariff reform," *Energy Networks Association* Position Paper, December 2014, 12.

83 Paul Austin, "Plug pulled on smart meter plan," *The Age*, 23 March 2010.

2013, with distribution utilities being required to offer domestic consumers with a choice of either a flat rate tariff or a time-of-use tariff.[84]

Recently, distribution utilities in the state have introduced optional demand charges and have advocated for tariff reform that would be more cost-reflective. For instance, in 2014, United Energy, a Victoria distribution utility, proposed a 2015 tariff that combined a flat rate energy charge with a maximum demand charge that varies by season. While the energy charge would remain constant at 2.5 cents year-round, the demand charge for residential use would be $7.10/kW/month in the summer period (December through March) and $2.80/kW/month in all other seasons. Demand would be measured as maximum actual demand between 15:00 and 21:00 over the entire month. There is no separate fixed charge in the tariff design, except that the demand charge assumes a minimum of 1.5 kW of demand per month. Note that United Energy's distribution use of system charge does not include a consumer's entire network use of system bill, as there are also separate charges for transmission use of system.[85]

In 2015 Jemena, another distribution utility, also proposed tariffs that added a time-of-use charges to the existing tariff structure.[86] They would offer a "general purpose" tariff with a demand charge of $2.42/kW in 2018; residential consumers would receive a fixed charge of $1.824 per month and an energy charge of 6.830 cents per kWh. Additionally, they would offer a "flexible" tariff with a fixed charge of $1.824 per month and a demand charge of $2.42/kW per month. The flexible tariff would have three energy prices; a peak, shoulder, and off peak energy charge of 10.102 cents/kWh, 6.830 cents/kWh, and 2.714 cents/kWh respectively. They would also offer a "time of use interval meter" tariff that would include a fixed charge of $1.824 per month and monthly demand fee of $2.42/kW. It would have two energy prices; a peak energy charge of 10.102 cents/kWh and an off peak energy charge of 1.913 cents/kWh.[87] Victoria's Energy Minister has announced that electricity tariff reform will continue to be implemented on an opt-in basis, rather than making this a standard feature of the default tariff offering.[88]

In addition to demand charges, there is interest in the potential benefits of locational variation in retail tariffs. In 2015 United Energy was conducting trials for critical peak rebates in areas of the grid most likely to exceed network capacity.[89] The trials are on-going and no findings have yet been released.

Relevance to GB

The Victoria case study is interesting in part because of its contrast to the Ontario case study. Whereas Ontario rolled out TOU rates on a default basis, the Victorian government is only allowing new tariff designs to be offered on an opt-in basis. This decision is in spite of a 2014 study indicating that new tariffs could lead to $8 billion in reduced infrastructure investment over the next five years and a recommendation in 2012 by the Australian Energy Markets Commission that domestic tariff structures be modified to be more cost reflective. It is believed that the

[84] "Towards a national approach to electricity network tariff reform," *Energy Networks Association* Position Paper, December 2014, 12.
[85] "Cost reflective pricing: engaging with network tariff reform in Victoria," *CUAC*, June 2015, 18.
[86] Ibid, p. 19.
[87] "Cost reflective pricing: engaging with network tariff reform in Victoria," *CUAC*, June 2015, 19.
[88] Tony Wood, "Victoria goes slow on electricity tariff reform," *Australian Financial Review*, 4 February 2016.
[89] "Cost reflective pricing: engaging with network tariff reform in Victoria," *CUAC*, June 2015, 19.

political hesitancy to allow new tariff designs is driven in part by a perception that the smart meters have not produced significant consumer benefits in Victoria.

Still, there appears to be support for mandatory tariff reform in Australia in the future. A consumer advocacy group recently released a report advocating for an 18-month transition period to new cost-reflective tariffs, with a heavy emphasis on education for consumers.[90] For GB, this contrast in philosophies between opt-in versus mandatory deployment illustrates that stakeholders in two similarly-situated markets can have different perspectives on what constitutes sound tariff design practices. Ultimately, the preferences of consumers, industry stakeholders, regulators, and policymakers will all play a role in shaping distribution tariffs.

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90 Ibid.

Section 7: Consumer bill impacts

Section 7 highlights:

- We analysed the bill impacts of the alternative tariffs for more than 11,000 domestic consumers in GB
- In the absence of price response, the IBR tariff produces bill savings for the average low income customer while the Higher Standing Charge and Demand Charge options increase the average customer's bill. The TOU rate produces modest average bill impacts.
- After accounting for price response, all tariffs other than the Higher Standing Charge produce average bill savings for low income consumers, highlighting the value of educating consumers about the new tariff and options that exist for reducing their electricity bill
- Both with and without price response, it is important to note that customers at the outer ends of the distribution of bill impacts will see savings or bill increases that are significantly larger than the average impacts
- An illustrative assessment of the potential "cost shift" from DG to non-DG consumers suggests that the IBR is less attractive for low income consumers, shifting more of the network cost recovery burden to consumers who do not have PV. The Demand Charge and Higher Standing Charge options (and possibly the TOU option) are more effective in addressing the cost-shift issue in current tariffs

If a new distribution tariff structure is introduced and it is passed on to domestic consumers in some form, consumers' bills will change.[91] With any change to the tariff's design, some consumers will experience automatic bill savings and others will experience a bill increase. Therefore, an important aspect of future rate reform activities will be to understand the distributional bill impacts that will result.

In this section of the report, we analyse the impacts of several alternative distribution charging structures on consumer bills. We rely on a large sample of actual consumer load data from two different locations within GB. Bill impacts are estimated both before and after a realistic level of consumer response to the rates (i.e., changes in consumption patterns in response to the new price signals).

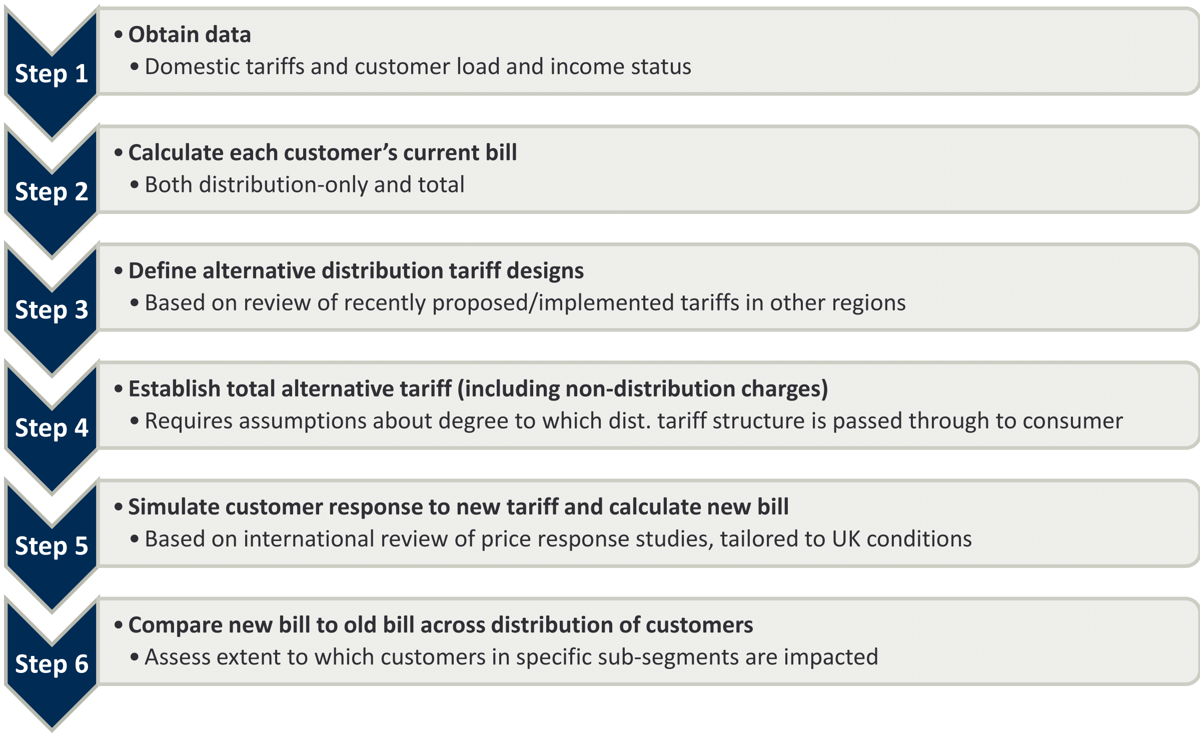
The focus of this analysis is on changes in tariff *structure*. Each of the rates analysed would produce the same revenue as the current tariff for the domestic class, in the absence of any change in consumption behaviour. In this sense, each of the alternative tariffs is considered to be "revenue neutral" to the existing tariff.

Data and Methodology

The overall methodological framework for analysing bill impacts is divided into seven steps. This process is summarized in Figure 5. The approach begins with gathering the necessary tariffs and consumer data. Bills are calculated for each consumer, price response is simulated, and the bill impacts are then compared across the distribution of consumers.

91 The eventual pass-through of a new distribution charging structure is a plausible outcome. For instance, current domestic tariffs offered by suppliers have the two-part structure of the distribution tariff. High voltage consumers see a direct pass-through of the distribution tariff.

Figure 5: Summary of Methodological Framework for Bill Impact Analysis



Consumer data

Half-hourly load data was obtained from two different field trials in GB. The Low Carbon London (LCL) field trial was focused on the greater London population and included data for 5,567 domestic consumers.[92] The Customer Led Network Revolution (CLNR) field trial included 9,201 domestic consumers in the Northern Powergrid service territory, which includes Newcastle and Durham.[93]

The dataset of more than 14,000 consumers was restricted to a subset of consumers with data that would be useful to this study. We kept any consumer in the dataset that met the following criteria:

- 12 consecutive months of consumption data during 2012-2013[94]
- Fewer than one per cent of consumption observations of 0 kWh
- Member of control group[95]
- Relevant associated sociodemographic data

[92] See "DNO Guide to Future Smart Management of Distribution Networks Summary Report," *UK Power Networks & Low Carbon London Learning Lab*, December 2014.

[93] See "Insight Report: Domestic Time of Use Tariff: a comparison of the time of use tariff trial of the baseline domestic profiles," Gavin Whitaker, Robin Wardle, Christian Barteczko-Hibbert, Peter Matthews, Harriet Bulkeley, Gareth Powells, *Customer-Led Network Revolution*, 23 January 2013.

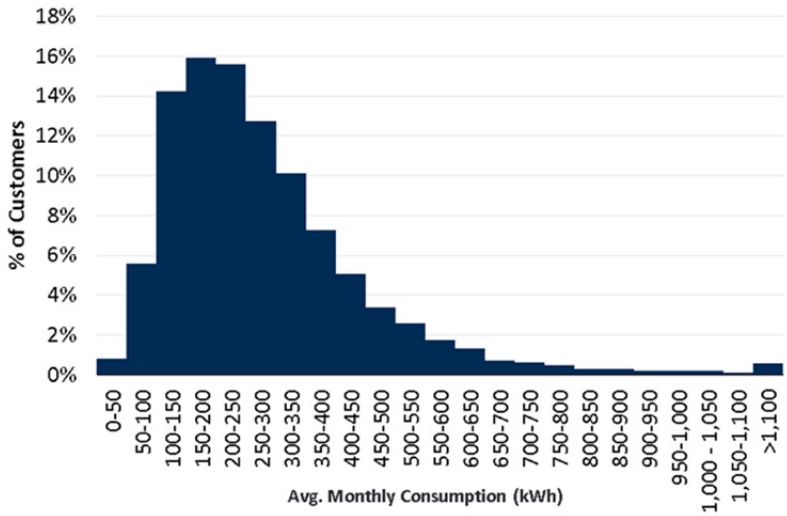
[94] Due to differences in data availability and the timing of the field trials, we used calendar year 2013 data for LCL consumers and September 2012-August 2013 data for CLNR consumers.

[95] Consumers in the control group in the field trials remained on the existing tariff. Consumers in the treatment groups were subject to TOU tariffs and likely changed their consumption patterns as a result, making them unrepresentative of the population of consumers who would be exposed to a range of tariff designs in our analysis.

Slightly more than 11,000 consumers remained in the sample after applying the above screens. While LCL consumers were located entirely within in the relatively urban greater London area, CLNR consumers were located in both urban and rural areas within the Northern Powergrid service territory. To maintain the largest possible sample from the given data, we pooled all of the consumers and did not attempt to rebalance the data between urban and rural consumers in a way that would attempt to represent GB as a whole. However, we did separately conduct analysis of the impacts on consumers in the two service territories to determine differences across the urban/rural designation.

The distribution of an average monthly consumption across the sample is illustrated in Figure 6. the sample has a mean monthly consumption of 283 kWh/month and a median of 243 kWh/month.

Figure 6: Average Monthly Consumption per Household in Combined Dataset



In addition to half-hourly load data, each consumer in the sample was pre-assigned to a category based on various sociodemographic characteristics. Wealth is an important driver of this categorization. Consumers in the LCL dataset were classified according to a market segmentation system called "Acorn," which assigns consumers to one of five categories.[96] The categories area as follows, sorted roughly from most to least affluent:

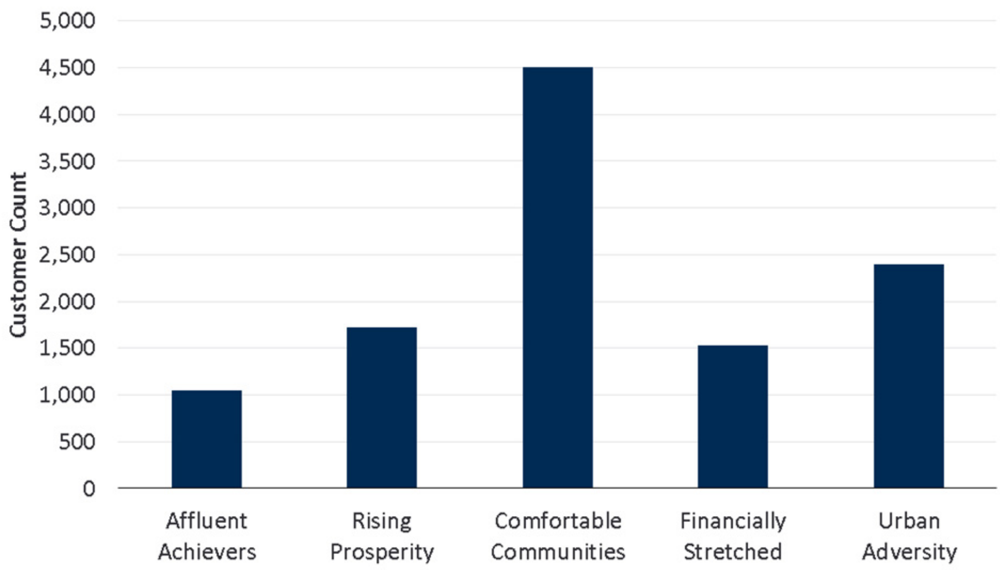
1. "Affluent Achievers": most financially successful people in the UK; mainly middle aged/older
2. "Rising Prosperity": younger, well educated, prosperous; many have substantial incomes but have not yet had time to convert into substantial savings/investments
3. "Comfortable Communities": much of "middle-of-the-road" Britain; all life stages represented; most people are comfortably off, with few major financial worries
4. "Financially Stretched": incomes well below average; many are getting by with modest lifestyles but a significant minority experiencing some degree of financial pressure

96 For more information about the Acorn classifications, see: http://acorn.caci.co.uk/.

5. "Urban Adversity": the most deprived areas of large and small towns and cities across the UK; people experiencing the most difficult social and financial conditions; household incomes are nearly always below national average

CLNR consumers were classified according to a different system, called "Mosaic." This classification system included 15 different consumer types.[97] We mapped the Mosaic consumer types into the five Acorn categories based on our interpretation of the qualitative descriptions in publicly available Mosaic documentation, with particular attention paid to any mention of income level.[98] Thus, the five Acorn categories described above are used throughout our analysis to characterize all consumers in the combined dataset according to degree of affluence. There is significant representation in the sample across the five Acorn categories, as shown in Figure 7.

Figure 7: Consumer Count in Combined Sample, by Acorn Group



Source: Low Carbon London and Customer Led Network Revolution. Analysis by The Brattle Group, on restricted dataset with mapping between Acorn and Mosaic categories based on income, as described above.

A common metric of interest is the extent to which household income is correlated to electricity consumption. It is often assumed that lower income consumers are also smaller consumers of electricity. This is true in the sample of consumers we analysed, though the correlation appears to be somewhat limited. There are, for instance, large consumers of electricity in the lower income categories (possibly consumers with electric space heating) and vice versa. Therefore, policies directed at protecting small consumers with the intent of protecting lower income consumers may only very approximately achieve the desired outcome. The relationship between electricity consumption and level of affluence is illustrated in Figure 8.

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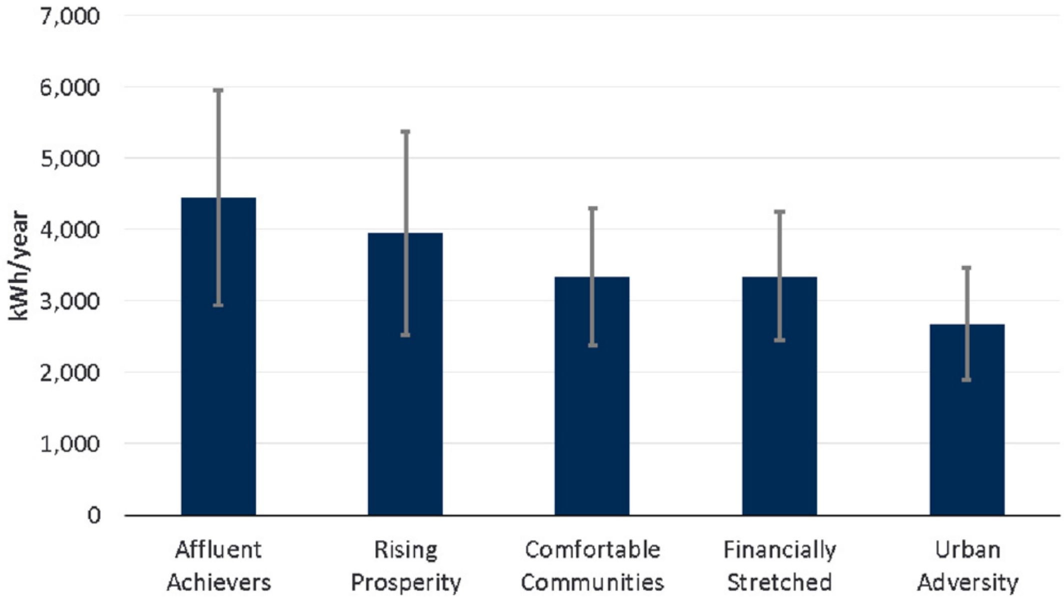
97 For more information about the Mosaic classifications, see: http://www.experian.co.uk/marketing-services/products/mosaic-uk.html.

98 See Appendix E for more detail on the mapping of Mosaic categories to Acorn groups.

Figure 8: Average Annual Electricity Consumption, by Acorn Group



Note: Range represents 10th and 90th percentile of electricity consumption.

The existing tariff

As was described in Section 2, most domestic consumers in GB have a "two-part" distribution tariff design with a standing (£/month) charge and a unit (p/kWh) charge.

Based on a review of national data on distribution charges across the DNOs, we have constructed representative distribution charges of £1.25/month and £0.0225/kWh as the baseline in the analysis.[99] For a typical domestic consumer with 260 kWh of average monthly electricity consumption (roughly 3,100 kWh/yr.), these illustrative distribution charges amount to a payment of about £7.10/month (£85/yr.).

Distribution charges account for roughly only 15% to 20% of the typical consumer's total electricity bill. The rest of the bill includes generation costs, transmission costs, various policy costs (e.g., clean energy subsidies), and a profit margin for suppliers. A review of national data suggests that the average total domestic electricity bill includes roughly a £5.75/month standing charge and a £0.14/kWh unit charge, amounting to a total monthly bill of £42/month for the typical domestic consumer with 260 kWh of monthly consumption. These total charges described above are inclusive of the previously discussed distribution charges.

The alternative tariffs

Alternative tariffs were developed for each of the four categories of tariff design described in Section 5. Specifically, we have considered tariffs with (1) a higher standing charge, (2) an inclining block unit charge, (3) a time-varying unit charge, and (4) a demand charge. In each

99 Roughly 20 percent of consumers are on the Domestic 2 Rate tariff, which includes a higher peak period unit charge and a lower off-peak unit charge; for simplicity, we focus only on the Domestic Unrestricted tariff in this analysis.

instance the alternative charges are designed to be revenue neutral. This means, for instance, that an increase in the standing charge would be offset by a proportional decrease in the unit charge.

Each alternative rate in this study was designed to be consistent with charges being proposed and implemented in other regions. As such, the designs reflect practical considerations from these jurisdictions. There are many ways to design each of the alternative tariffs, which could be explored through further analysis. The basic logic behind the design of each tariff option is as follows:

Higher Standing Charge: The standing charge is increased and the unit charge is decreased relative to the existing tariff. Consistent with price levels observed previously in GB standing charges, we have assumed a structure that recovers roughly half of total distribution costs through the standing charge, as opposed to 20 per cent in the current tariff.

Inclining Block Rate (IBR): The first 100 kWh of a consumer's monthly consumption is charged at a reduced unit price and the remaining consumption is charged at an increased price. We have assumed a two-tiered IBR with a roughly a 3-to-1 ratio in the prices of the two tiers. This is within the high end of the range of IBRs being offered by utilities in other jurisdictions, such as California.

Time-varying unit charge: While there are many options for making the unit charge time-varying, for simplicity in this analysis we have modelled a simple, two-period TOU rate. The unit price is higher during peak hours (17:00 to 22:00, weekdays) and lower during all other hours. We have assumed a TOU rate with a 7-to-1 price ratio. This is a relatively high price ratio, designed to reflect the fact that distribution system costs are largely peak-driven. It is smaller than the price ratio of the Red-Amber-Green tariff for larger consumers.

Demand charge: A demand-based charge is introduced as a third charge in the tariff, next to the standing and unit charges. It is based on a consumer's maximum hour of demand each month.[100] We have assumed a demand charge that recovers roughly half of distribution costs.

A side-by-side summary of the charges in each alternative tariff design is provided in Table 2.

[100] For simplicity, we have assumed that the demand charge is based on each individual consumer's maximum demand. A common alternative design is to restrict the measurement of demand to peak hours of the day (i.e., the window of hours when load on the distribution system reaches its peak). Those in favour of this alternative design argue that it better aligns the price signal with the driver of distribution system costs. In future research, it would be useful to analyse the impacts of this peak-constrained demand charge.

Table 2: Summary of Alternative Distribution Tariff Designs

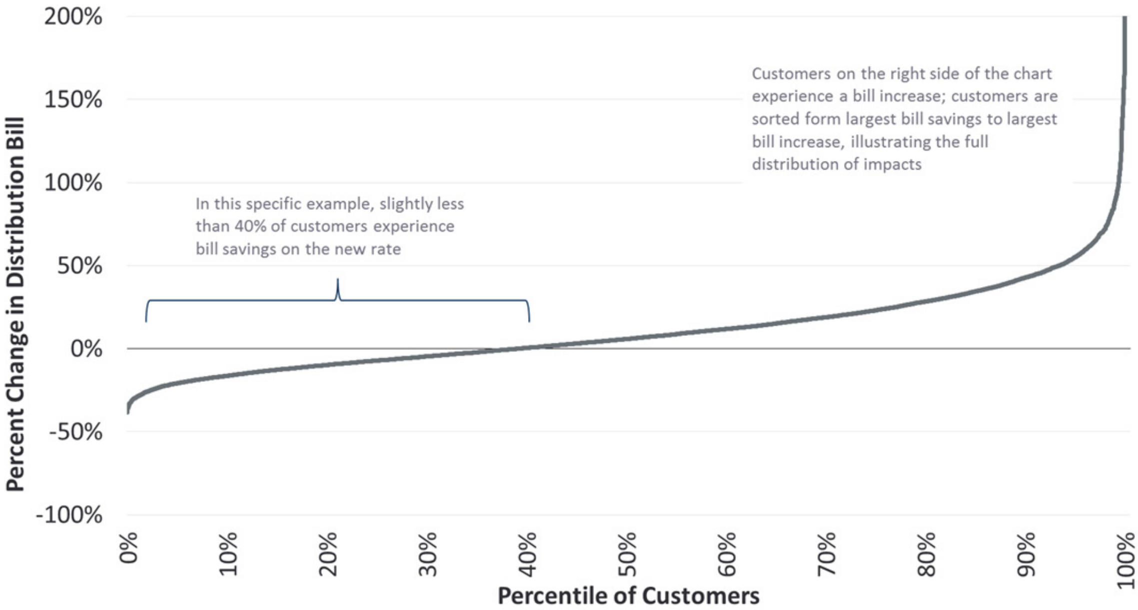
	Existing distribution charges	Higher Standing Charge	IBR	Demand Charge	TOU
Standing charge (£/mo)	1.25	3.99	1.25	1.25	1.25
Demand charge (£/kW)	N/A	N/A	N/A	1.59	N/A
Flat unit charge (p/kWh)					
All consumption	2.25	1.28	N/A	0.80	N/A
Tiered unit charge (p/kWh)					
Tier 1 (first 100 kWh/month)	N/A	N/A	1.00	N/A	N/A
Tier 2 (remaining kWh/month)	N/A	N/A	2.90	N/A	N/A
Time-varying unit charge (p/kWh)					
Peak (17:00 to 22:00, weekdays)	N/A	N/A	N/A	N/A	5.60
Off-peak (all remaining hours)	N/A	N/A	N/A	N/A	0.79

Note: Only distribution charges are shown.

BILL IMPACTS WITHOUT CONSUMER RESPONSE

Bill impacts can be effectively illustrated using a chart like that shown in Figure 9. This is sometimes referred to as a “propeller chart.” The chart illustrates the distribution of annual bill impacts across consumers when switching from the existing tariff to one of the alternative tariffs. Consumers on the left side of the chart are those experiencing bill savings and consumers on the right side of the chart are those experiencing a bill increase. The chart shows the percentage change in the distribution portion of the consumer’s bill, assuming each consumer was exposed to the change in tariff structure. In this specific example, slightly less than 40 percent of consumers experience bill savings on the new rate. Some consumers see a sizeable bill increase in percentage terms.

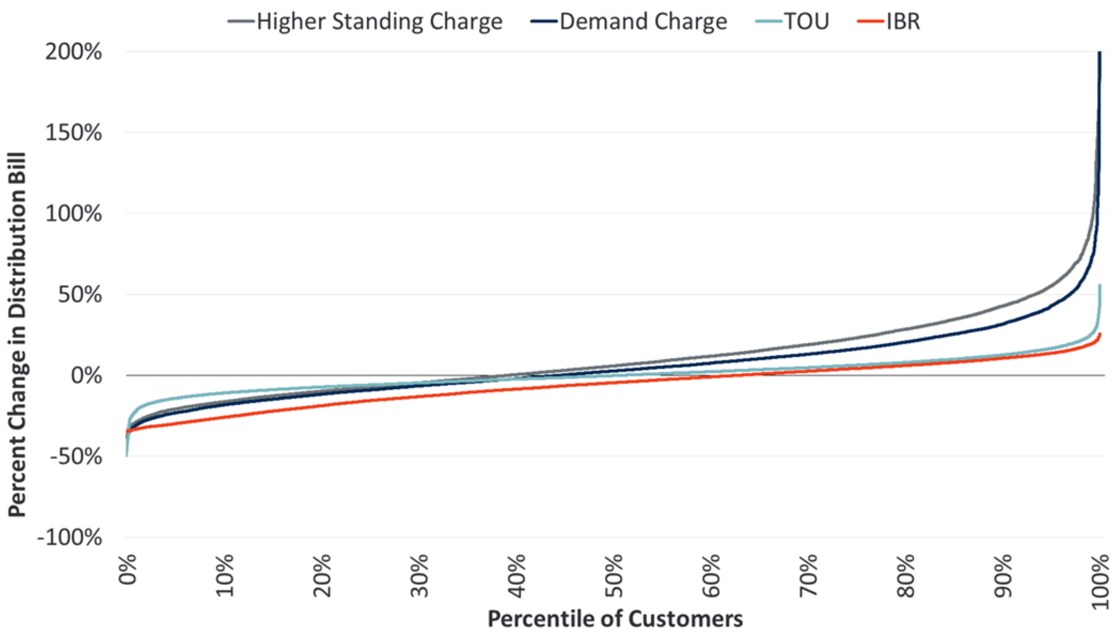
Figure 9: Impacts of Higher Standing Charge on Distribution Portion of Bill



Note: These impacts are before any price response. For ease in presentation, a few outliers at the extreme right end of the figure have been excluded.

As modelled, demand charges and higher standing charges produce more dramatic bill changes (both bill increases and decreases) than IBR and TOU designs. The IBR produces leads to the largest number of consumers with bill savings by virtue of benefitting smaller consumers with a rate discount. A comparison of bill impacts across the four alternative tariff designs is illustrated in Figure 10.

Figure 10: Bill Impacts for the Four Alternative Tariff Designs



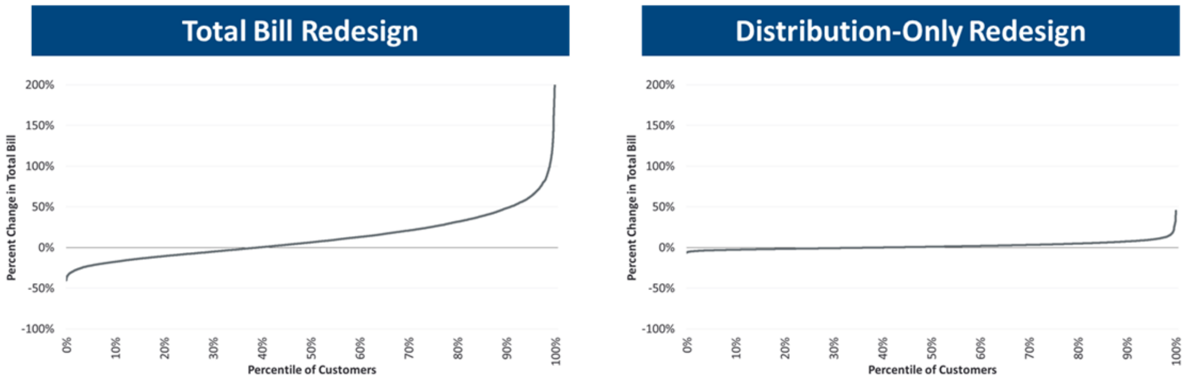
Note: Bill impacts shown are before any price response. Bill impacts are for for distribution portion of the bill only. For ease in presentation, a few outliers at the extreme right end of the figure have been excluded.

As discussed in Section 2, the design of the tariffs that are ultimately offered to consumers is determined by the suppliers. The structure of the new distribution charges may not necessarily be reflected in the consumers' final tariff. This is a critical area of uncertainty in the analysis, because we do not know the extent to which changes in distribution tariffs will translate into new price signals to consumers. At one extreme, changes to the distribution tariff structure may be totally hidden from consumers. At the other extreme, the suppliers might begin to offer new options that resemble these alternative distribution tariff structures. In recognition of this uncertainty, we model two scenarios (Appendix C includes a summary of the total charges in each scenario):

- **"Distribution-only Redesign":** The consumer's bill is bifurcated into distribution and non-distribution charges; consumers directly see the change in distribution charges, but the non-distribution portion of their bill remains unchanged.
- **"Total Bill Redesign":** All non-distribution charges are adjusted proportionally such that the share of revenue from each charge in the total tariff is the same as the share of distribution revenue from each charge in the distribution rate.

A consumer's total bill will change to a much greater extent if non-distribution charges are modified proportionally to distribution charges. If the non-distribution charges do not change, the relatively small share of distribution charges in the total bill leads to very modest total bill changes. Figure 11 illustrates this comparison of changes in the total bill, with the Total Bill Redesign scenario shown on the left and the Distribution-Only Redesign scenario on the right. Throughout the rest of this report, unless otherwise noted, we present changes in the distribution portion of the bill

Figure 11: Comparison of Total Bill Redesign and Distribution-Only Redesign Scenarios



Note: Results illustrated for Higher Standing Charge tariff. For ease in presentation, a few outliers at the extreme right end of the figure have been excluded.

An important policy consideration will be the impact of the alternative tariffs on lower-income consumers. Analysis of bill impacts for the five Acorn groups provides insight into the impacts on consumers of different income status.

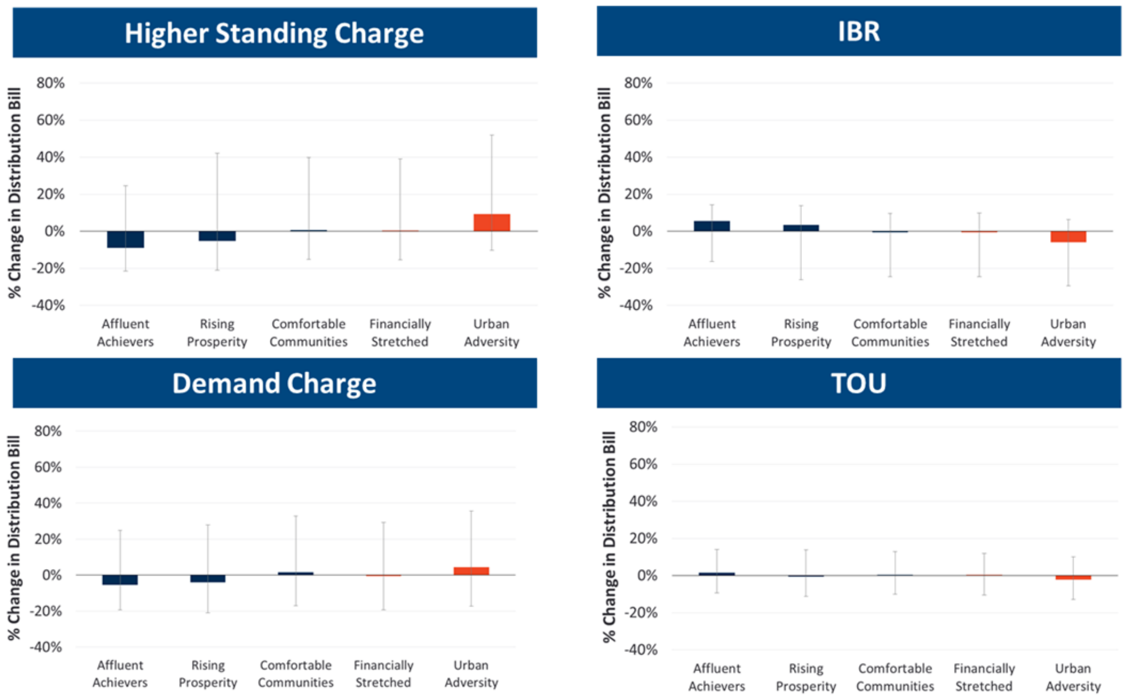
Generally, as modelled in this analysis, the Demand Charge and Higher Standing Charge options both tend to increase bills *on average* for the least affluent consumers and decrease bills for the most affluent consumers. However, it is important to note that there are consumers experiencing bill increases and decreases in both groups.

The IBR has the opposite effect, causing bills to go down on average for less affluent consumers. It is important to note, though, that there is likely a group of low income consumers with large monthly usage due to electric heating, older and poorly insulated homes, and less efficient appliances. These consumers would see a bill increase under an IBR tariff. The magnitude of impacts with the IBR is much more modest than with the Demand Charge or Higher Standing Charge options.

The TOU rate has a very modest effect on bills, with the vast majority of consumers experiencing bill increases or decreases of less than ten per cent.

The impacts on consumer bills by alternative tariff and Acorn group are illustrated in Figure 12. The least affluent consumer segments are highlighted in red. The "error bars" in the charts represent bill impacts for the 10th and 90th percentile of consumers in that Acorn Group.

Figure 12: Change in Average Distribution Bill by Acorn Group



Notes: Range represents 10th and 90th percentile of bill change. Least affluent consumer segments highlighted in red.

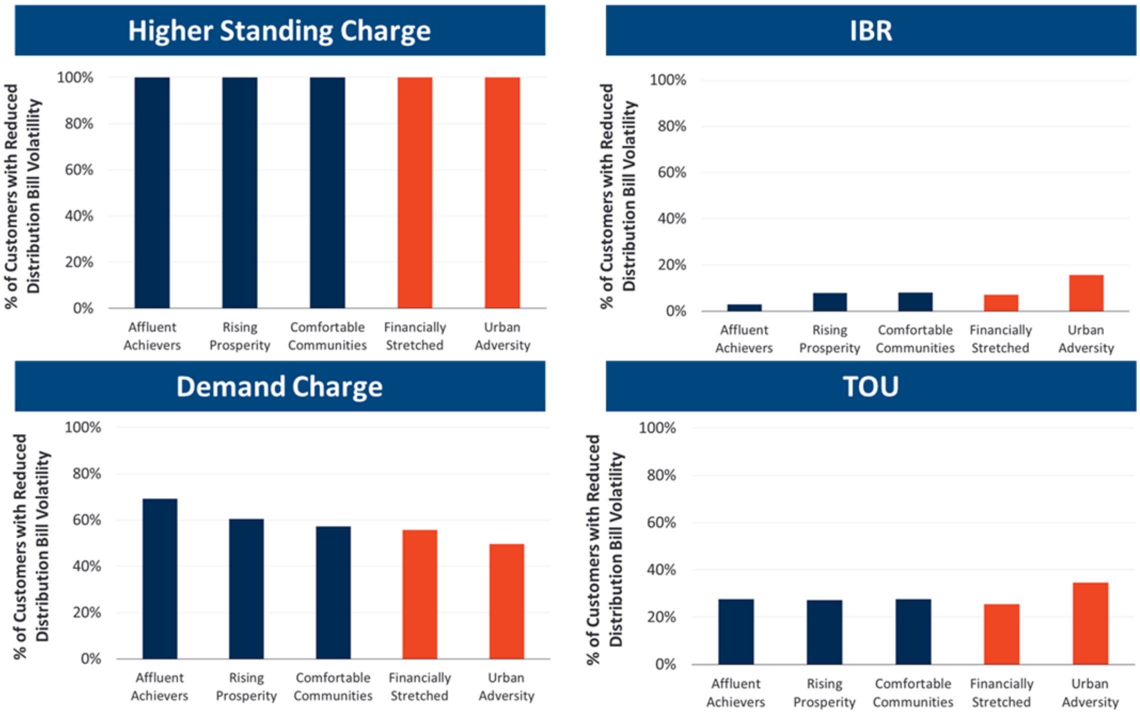
In addition to quantifying the change in the total bill amount for each consumer, we have also analysed the change in month-to-month bill volatility. Bill volatility is measured on an individual consumer basis as the standard deviation in the consumer's 12 monthly bills. Bill volatility is a relevant consideration because it represents the extent to which consumers will experience an increase or decrease in bill stability.[101] Even if a new tariff leads to an overall reduction in the average bill, unpredictable bills could be negatively received by consumers.

Overall, the Higher Standing Charge option reduces bill volatility for all consumers by collecting a greater proportion of revenue through a fixed monthly fee. The IBR increases bill volatility for most consumers, by exposing a portion of their consumption to a higher-than-average price. The demand charge decreases bill volatility for about three quarters of high income consumers and half of low income consumers. The TOU option decreases bill volatility a little less than half of

[101] It is possible that suppliers would choose to absorb this volatility in the distribution bill by offering various types of tariff price guarantees.

the consumer base, with fairly even impacts across income levels. A summary of the share of consumers experiencing a reduction in bill volatility is presented in Figure 13.

Figure 13: Share of Consumers Experiencing Decrease in Monthly Distribution Bill Volatility



Notes: Least affluent consumer segments highlighted in red.

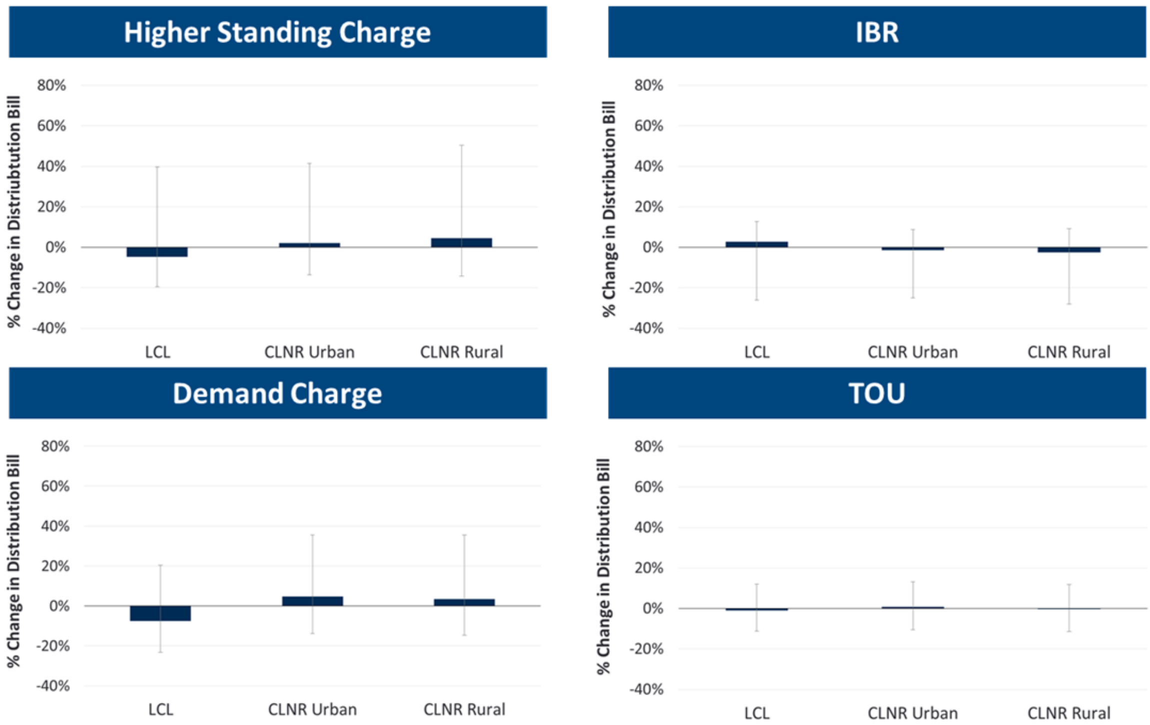
The data also allows for a comparison of bill impacts for urban versus rural consumers. Consumers in our analysis were spread across London as well as urban and rural areas within the Northern Powergrid electricity network (which includes the cities of Newcastle and Durham). We divided consumers in the CLNR data into "Urban" and "Rural" groups based on our interpretation of the Mosaic consumer type definitions, allowing for analysis of bill impacts based on whether consumers living in an urban versus rural setting.[102]

Note that we have modelled tariffs that are revenue neutral across the entire sample of consumers. Any differences in bills across these consumer groups are therefore driven entirely by the change in tariff structure and not differences in average price levels across the service territories.

The urban versus rural distinction does not appear to be a strong driver of differences in average bills. The higher standing charge and demand charge rates result in slightly lower bills for London consumers and slightly higher bills for other urban and rural consumers. The IBR rate exhibits the opposite pattern of effects, although the bill impacts are very small (a change of less than five percent for the majority of consumers). The TOU rate has negligible average effect on all regional groups. A summary of bill impacts by regional grouping is shown in Figure 14.

102 The Mosaic definitions are based on multiple consumer demographic factors, and therefore this division between urban and rural is only approximate. Post codes were not included in either dataset, but would be helpful in refining the classification of consumers as urban versus rural.

Figure 14: Distribution Bill Impacts by Regional Grouping



Notes: Range represents 10th and 90th percentile of bill change.

BILL IMPACTS WITH CONSUMER RESPONSE

Modelling consumer price response

While a static analysis of bill changes is useful for understanding consumer impacts in the absence of price response, evidence suggests that consumers will change their electricity consumption patterns in response to a new tariff design. An international survey identified more than 40 domestic pricing pilots conducted over the past dozen years. Each pilot contains multiple treatments (i.e. rate options), with more than 200 treatments tested across the pilots.[103] The vast majority of these detected statistically significant peak demand reductions in response to higher peak period prices.

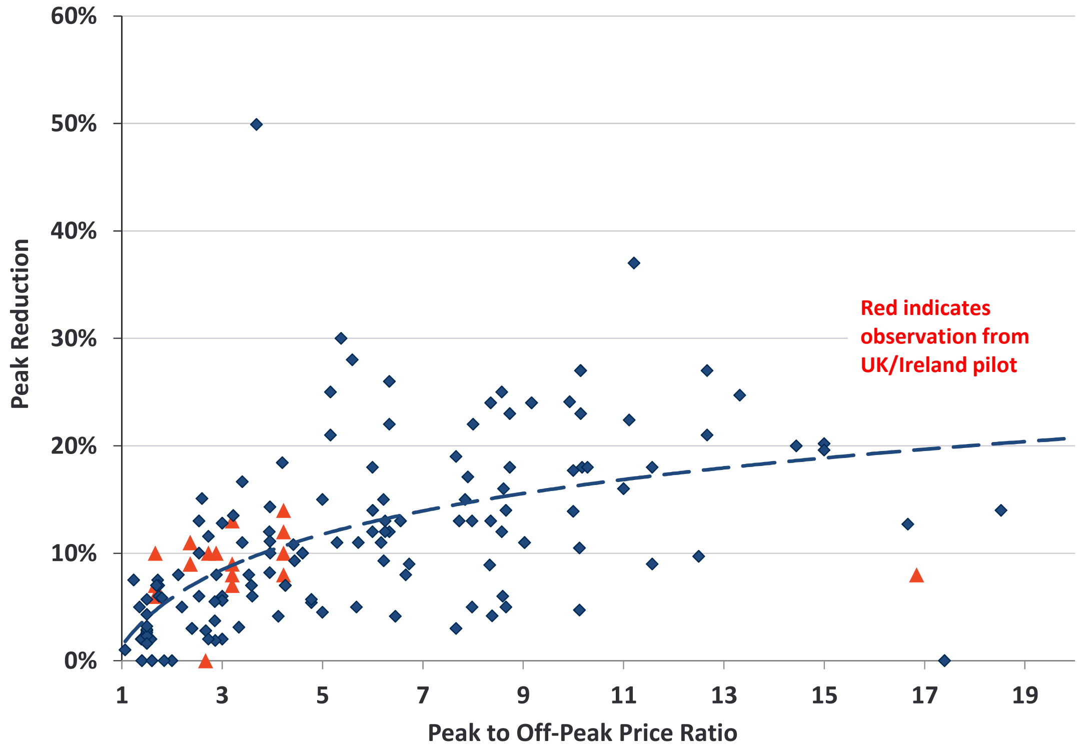
The results of the pricing pilots can be organized across two key dimensions – price ratio and peak demand reduction. Fitting an arc to this data shows that price response increases with a stronger price signal, though it increases at a diminishing rate, suggesting that consumers eventually run out of practical actions that can reduce peak demand.

Of the more than 40 pilots surveyed, four were conducted in GB and Ireland. Price response in GB does not appear to be materially different than in other regions (when expressed as a percentage of peak demand). Given that there is no clear difference between the results of GB/Ireland studies and the other pilot studies, we use the arc to model consumer response to the alternative tariff designs in this analysis. The findings of the pricing pilots are summarized in

103 For discussion of an earlier version of this survey, see Ahmad Faruqui and Sanem Sergici, "Arcturus: International Evidence on Dynamic Pricing," *The Electricity Journal*, August/September 2013.

Figure 15. Note that the results shown only account for behavioural response and not the potential incremental impacts of automating technologies such as smart thermostats. Such enabling technologies could significantly boost the level of price response.

Figure 15: Peak Demand Reductions from Recent Domestic Time-Varying Pricing Pilots



Results shown only for price ratios less than 20-to-1 and for treatments that did not include automating technology such as smart thermostats.

To model consumer response to the four alternative tariff options, we account for two different effects of price on consumption: the "average price effect" and the "marginal price effect."

As was shown earlier this section, with the introduction of the new tariff, a consumer's total bill will increase or decrease. Studies by researchers at the University of California at Berkeley have found that consumers respond to changes in their total bill (i.e., changes in the average price).[104] An increase in the average price leads to a reduction in consumption and vice versa. This is the **average price effect**.

Consumers will also respond to a change in the rate structure, specifically the marginal prices that they face. In the case of a TOU or demand charge, this means shifting load from higher-priced hours to lower-priced hours, or away from hours with high demand. With an IBR, this means increasing consumption if consumers are in the lower-priced first tier, or decreasing consumption in the higher-priced second tier. With a higher standing charge, this means increasing consumption in response to the lower unit charge. This type of behavioural response is captured in the **marginal price effect**.

[104] Koichiro Ito, "Do Consumers Respond to Marginal or Average Price?" *American Economic Review*, Vol. 104, Issue 2. 2014, pp. 537-563.

Modelling both the average and marginal price effects requires an assumptions about the extent to which consumers are price responsive. Price elasticities are a quantitative representation of the extent to which consumers will change their electricity consumption in response to a price change. Consumers with higher price elasticities will reduce (or shift) more of their electricity consumption in response to a price increase. To estimate the average price effect, we assume an "own price elasticity of demand for electricity" of -0.15. This is a conservative estimate based on a meta-analysis of "own price elasticities of demand for electricity" in the UK.[105] To estimate the marginal price effect for the higher standing charge and the IBR, we also use a price elasticity of -0.15. This is on the conservative end of assumptions used in prior studies by Brattle. And to estimate the marginal price effect for TOU and demand charges, we use the arc shown in to capture load shifting.

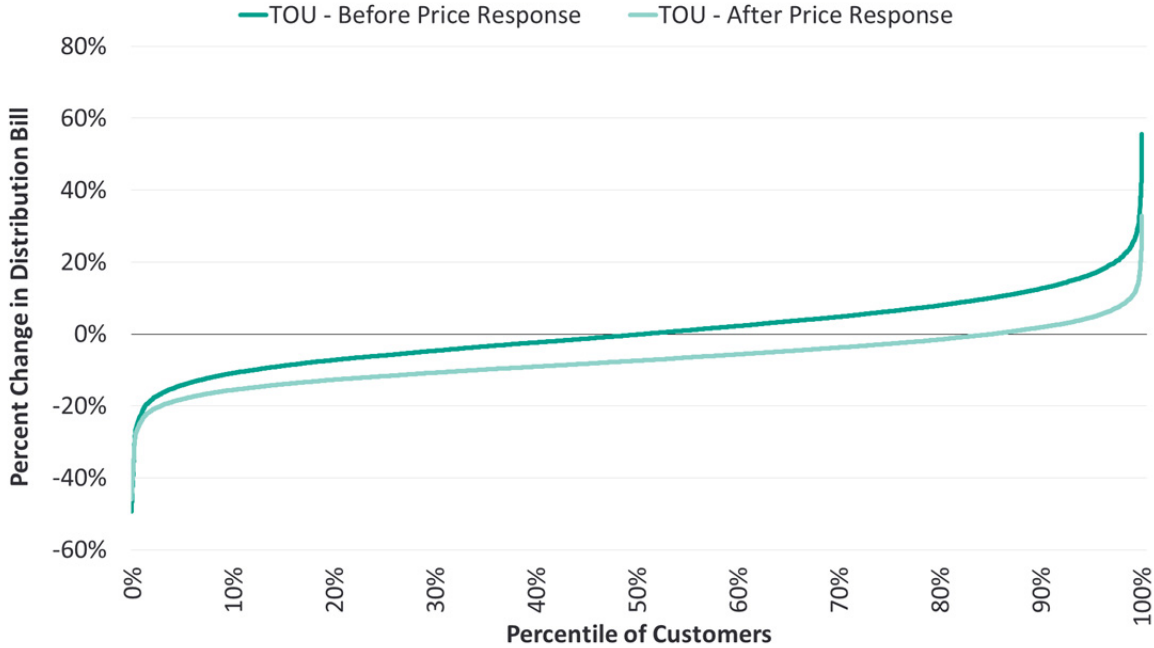
Finally, it is worth noting that there is evidence that research suggests that lower income consumers respond to new tariff structures. Several studies in the U.S. have found that low income consumers are price responsive, though in some cases to a lower degree than other consumers. Given the lack of empirical data on this relationship in GB, we have not differentiated price responsiveness across the various consumer groups; this could be tested by further research into sensitivity analysis.

The impact of price response on bills

Price response is an opportunity for consumers to save money on their electricity bills. In the case of the time-varying unit charge in this study, for example, the share of consumers experiencing bills savings increases from approximately 45 per cent without price response to around 80 percent after accounting for consumption being shifted away from higher priced peak period hours. This is illustrated in Figure 16, which contrasts propellers for the TOU tariff both before and after price response.

[105] Michael Smyth and Mark Bailey, "An economic analysis for the elasticity of demand for energy in Northern Ireland," prepared for the Northern Ireland Authority for Utility Regulation. http://www.uregni.gov.uk/uploads/publications/NIAUR_Report_UU_revised.dochttp://www.uregni.gov.uk/uploads/publications/NIAUR_Report_UU_revised.doc

Figure 16: Distribution Bill Impacts Before and After Price Response for the TOU Tariff

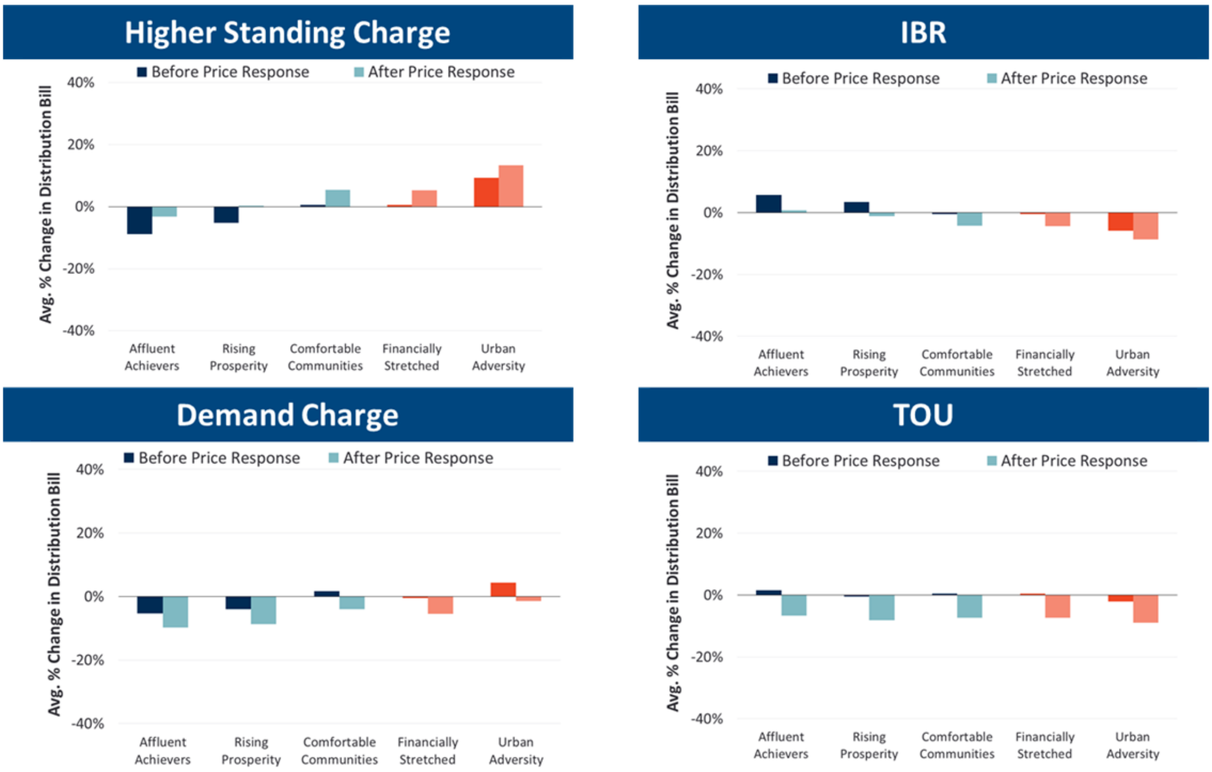


Note: Results shown for Total Bill Redesign scenario.

The impacts of price response on consumer bills and utility revenues will change over time. In the very near term, price response will reduce bills for those consumers who choose to respond. In the medium-term, utilities may raise prices for all consumers in order to make up for the lost revenue between price control periods. In the longer-term, with a well-designed tariff, consumer response will lead to a more efficient load profile, which will reduce the utility's costs and should lead to bill savings for all consumers. Results presented in this report are focused on quantifying the near-term impacts of price response on consumer bills.

Across the four tariff design options, average bills are reduced due to price response for three of the four options. In the case of the higher standing charge, the average bill actually increases after price response. This is because all consumers face a lower unit charge with this tariff option. Their marginal price has decreased, and they have an incentive to consume more as a result. This should not be interpreted as a *rate increase*, however. The fact that consumers use more electricity is an indication that they are benefitting from consuming more of a product with a lower marginal price. Average bill impacts for each Acorn group before and after price response are summarized in Figure 17. In many cases, consumers experiencing a bill increase before price response can experience bill savings relative to the current tariff by changing their consumption patterns.

Figure 17: Share of Consumers with Distribution Bill Savings, Before and After Price Response



Note: Results shown for Total Bill Redesign scenario. Least affluent consumer segments highlighted in red.

The impact of PV adoption on tariffs

Central to the move toward new distribution tariffs is a desire among utilities and regulators to establish a tariff design that will better reflect the cost of delivering electricity in an environment of increasing adoption of DG -rooftop solar in particular. As described in Section 3, with largely volumetric tariffs the owners of solar PV systems could size the system in such a way that they virtually zero out their electricity bill, while still benefitting from their connection to the grid. The utility then recovers its investment in the grid for these consumers through a tariff price increase, the burden of which primarily falls to non-owners of rooftop PV.

The extent to which this "cost shift" from DG consumers to non-DG consumers will be mitigated by the new distribution tariff will depend on its design. Some of the tariffs discussed in this report will reduce the tariff price increase associated with DG adoption, while others could potentially amplify it.

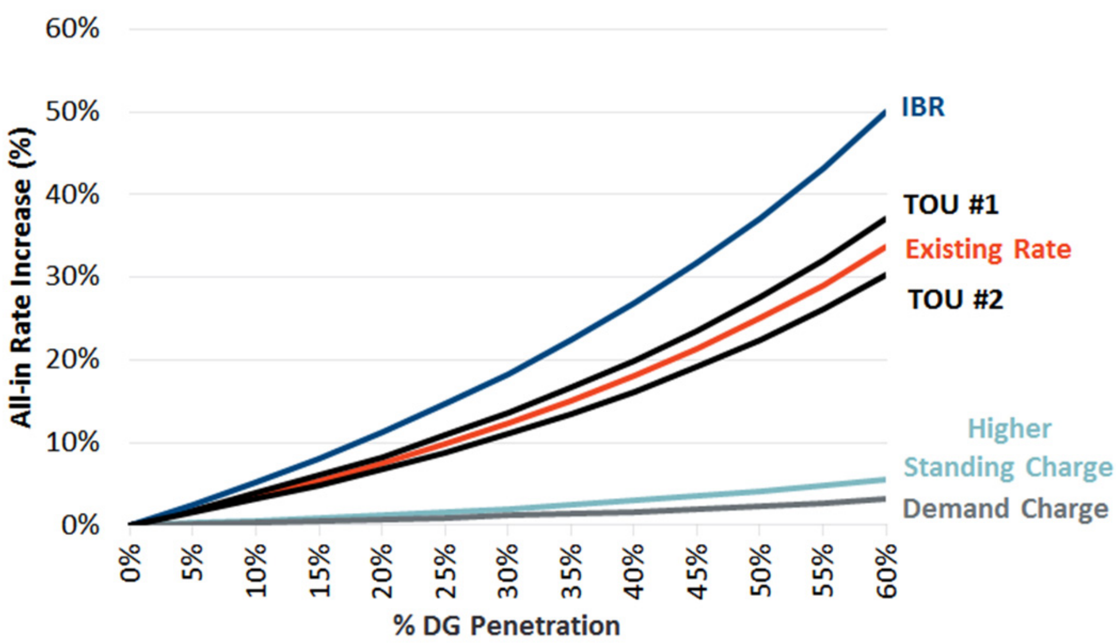
To illustrate this relationship, we constructed a very simple, stylistic model of distribution system costs. Relying largely on the previously described sample of consumer load data, we constructed a load profile for a typical consumer. This was combined with plausible but illustrative assumptions about the extent to which a rooftop PV installation would impact the consumer's net load profile. We then calculated the extent to which each of the four alternative tariff options would under-recover distribution costs from a consumer with PV. The findings were extrapolated to the population of consumers assuming various market penetration levels of rooftop PV. For a detailed list of assumptions in this analysis, see Appendix B.

The result of the simple modelling exercise shows that two of the tariffs modelled in this study – the Higher Standing Charge option and the Demand Charge option – significantly reduce the cost shift between PV and non-PV consumers. In contrast, the IBR increases the cost shift by compensating PV consumers a higher than average price for avoiding consumption in the second price tier.

The extent to which the TOU rate addresses the cost shift issue is highly sensitive to the timing of the peak period. If the output of the PV system does not reduce distribution network peak demand, but the period of the TOU aligns closely with peak output from the PV system, it is possible that this will lead to under-recovery of distribution costs. Alternatively, if the TOU peak period reflects the timing of the distribution system peak, and this does not overlap with the output of the PV system, this could improve the cost-shift issue. To reflect the sensitivity of the timing of the TOU peak period in this regard, two TOU tariff designs were modelled. TOU #1 has a peak period that is closely aligned with PV output, while the peak period of TOU #2 has less overlap.

Figure 18 illustrates the price increase associated with a range of PV market penetration scenarios.

Figure 18: Distribution Tariff Price Increase at Various Levels of DG Adoption



Recent data produced by DECC indicates that there is a strong correlation between income and adoption of rooftop PV.[106] If low income consumers are not among the group of consumers installing PV in the scenario described above, then the price increases summarized in Figure 18 would translate into bill increases for those consumers. Therefore, while certain tariff structures such as the IBR appear to be financially beneficial to low income consumers in a static environment without DG adoption, they could have the opposite impact as adoption of rooftop PV grows.

[106] DECC, "Identifying Trends in the Deployment of Domestic Solar PV Under the Feed-in Tariff Scheme." https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/79092/5648-trends-deployment-domestic-solar-pv.pdf

In designing new tariffs, it will be important to ensure that the design allows owners of distributed resources to capture the full value of the capacity benefits that they provide. For example, to the extent that output from rooftop solar panels is coincident with the distribution system peak, the tariff should allow the owners of the PV installations to benefit from the reduction in distribution capacity costs that they enable.

The purpose of this hypothetical example is to illustrate the relative impact of new tariff designs in an environment of rising DG adoption. It is important to note that this is a highly stylized example. More sophisticated utility-specific analysis would better account for the nuances of this issue. For example, the rate increases shown here do not reflect additional utility costs associated with net metering, such as interconnection and billing administration costs. The example also does not account for increases in distribution system costs that might occur when DG is adopted in very large numbers, with significant bi-directional flows of electricity on a given feeder. At high levels of PV adoption the timing of the system peak could also shift significantly, and additional system flexibility would likely be needed in demand or generation resources.

An increase in generation from rooftop solar is likely to reduce wholesale energy prices, an impact which is not reflected in this analysis of distribution system costs. Great Britain also has strong climate change goals, which would need to be considered from a policy perspective. A more nuanced modelling approach that accounts for factors such as these would be a valuable future research activity.

Conclusions of bill impacts analysis

In a static environment, without price response or high levels of market penetration of rooftop PV, the IBR appears most likely to produce automatic bill savings for less affluent consumers. The demand charge and higher standing charge options are more likely to produce bill increases for those consumers in this setting. The bill impacts of TOU rates are fairly modest.

After accounting for a realistic degree of price response, all options other than the higher standing charge lead to average bill savings for less affluent customers. This finding particularly highlights the importance of consumer outreach and education in any transition to a new distribution tariff design; if consumers understand the tariff and their options for responding to it, they have an opportunity to save money.

On average, bill impacts of the new tariff structures for low income consumers do not appear likely to be very large. For virtually any alternative tariff structure, the charges can be designed such that most consumers will experience only a modest change in the distribution portion of their bill. However, there will be a minority of consumers at the extreme end of the distribution who will experience significant bill changes. The development of a tariff transition plan will be critical for these consumers. Tariff transition plans are discussed in more detail in Section 8.

In some instances, our findings are contrary to the findings of similar analyses in other regions, largely the U.S. (where we have found, for example, that demand charges can reduce average bills for low income consumers). This is likely due to differences in weather and the housing and appliance stock of the consumer base in these respective markets. This highlights that the findings of a bill impacts study such as this can change from one utility service territory to the next, potentially even within GB.

The extent to which suppliers convey new distribution charging structures to consumers will play a critical role in determining consumer bill impacts. While the distribution tariff structure is passed through to high voltage consumers, it is not a separate line item on the bill for domestic consumers. Further, distribution charges account for only 15% to 20% of the total bill. These factors may limit the magnitude of consumer impacts resulting from a change in distribution tariff structure, unless suppliers begin to adopt more innovative tariff designs.

An assessment of the potential “cost shift” from DG to non-DG consumers – and ways to mitigate it that are consistent with GB’s clean energy goals - is an important consideration. Directionally, accounting for this impact at high levels of DG adoption is likely to make the IBR less attractive for low income consumers and the demand charge and higher standing charge options (and possibly the TOU option) somewhat more attractive. While a stylistic analysis has been presented here, this is an area that would benefit from more detailed future analysis.

Ultimately, it is important to note that consumer bill impacts are only one of many important considerations in tariff reform activities. Fairness, economic efficiency, simplicity, predictability, impact on emerging energy technologies, and other tariff design criteria are also key considerations.

Section 8: Making the Transition

Great Britain is still in the early stages of confronting the distribution tariff design issue. Interest in the role that distribution tariffs could play in promoting demand-side flexibility, combined with the move to smart meters and growth in the adoption of rooftop PV, all could potentially accelerate this activity in the future.

The extent to which distribution tariff reform could impact consumers in GB hinges on two important factors. The first factor is the degree to which consumers will be exposed to the structure of the alternative distribution tariff. If that structure is not passed on to consumers by suppliers, then from the consumer's perspective there will be little noticeable impact in their final bill. Alternatively, if the distribution tariff structure is passed on to consumers in some form, then the issues, considerations, and opportunities raised in this report become much more relevant.[107] The second factor is the future of half-hourly settlement for domestic consumers. From a practical perspective, half-hourly settlement will be necessary for many of the alternative tariff designs discussed in this report to be offered.

This study does not propose a specific distribution tariff design for Great Britain. Rather, we have identified important considerations for evaluating a range of alternative tariff design options. In particular, it is important to avoid the trap of evaluating the merits of a tariff's design based on a single criterion. Tariff design is an exercise in balancing trade-offs, with many competing criteria that should be taken into account.[108]

For instance, the consumer bill impacts highlighted in this report are a critical consideration when evaluating a new tariff design. Most jurisdictions – including GB – place a high priority on protecting all consumers from untenable bill increases, particularly consumers with limited income. But other aspects of the tariff design, such as a relationship to the underlying cost structure, will also be important. This broad view of tariff design is necessary to identify alternative tariff structures which could benefit all consumers in the long run, particularly as new energy technologies reach the market to open up previously unanticipated bill savings opportunities.

Given that GB's smart metering rollout and the transition to half hourly settlement are still several years away from completion, there may be a perception that it is too early to be evaluating alternative tariff designs. In fact, the opposite may be true. The next few years can be used to productively debate the merits of the new designs and identify the trade-offs that best suit the preferences of a diverse range of industry stakeholders. This time can also be used to test the impacts of new distribution tariffs on suppliers and consumers in a controlled environment through pilot programs and primary market research. Not only would new pilots help to identify any technical challenges in transitioning to the new tariff design, they also can be used to determine which tariff designs and educational messages best resonate with consumers.

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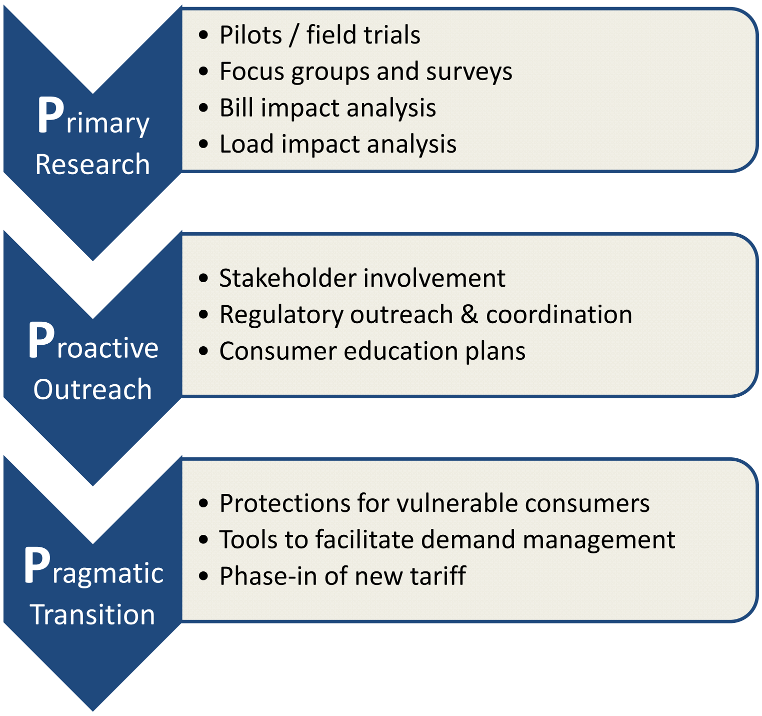
107 In GB, in the absence of a policy decision to pass through the distribution tariff as a separate line item on the consumer's bill, it will be up to the supplier to decide whether or not to modify the total tariff structures to reflect the underlying structure of the distribution tariff. In some instances, particularly with half-hourly settlement, suppliers may choose to manage a customer's load to avoid higher priced hours of the distribution tariff.

108 The five key principles of tariff design proposed earlier in this report are economic efficiency, equity/fairness, consumer satisfaction, utility revenue stability and consumer bill stability.

THE "THREE P'S" OF DOMESTIC TARIFF REFORM

Several important activities will help to productively move forward with a consensus-oriented approach to domestic distribution tariff redesign. We refer to these activities as The Three P's of Distribution Tariff Redesign. They are: primary research, proactive outreach, and pragmatic transition.

Figure 19: The "Three P's" of Distribution Tariff Redesign



Primary research includes those activities that are necessary to answer important questions about the potential impacts of a transition to an alternative tariff design. Examples of questions to be addressed through primary research include: How will the bills of low-income consumers be impacted? What messages are most effective in communicating the rates to consumers? To what extent will consumers modify their electricity consumption patterns in response to the new tariff structure? Will these new load patterns lead to bill savings? If so, will they similarly reduce system costs? How will the new tariffs impact the economics of behind-the-meter technologies such as PV solar, battery storage, and electric vehicles? Will the new tariffs affect the economics of energy efficiency? While these questions have been answered to varying degrees through research activities in GB and other jurisdictions, new research initiatives such as pilots, focus groups, consumer surveys, and model-based simulations can go a long way toward more definitively addressing these questions.

Proactive outreach involves coordination with consumers, stakeholders, and regulators. Consumers will need to be educated about the new tariff, how it could impact their bill, and what tools are at their disposal to manage demand and reduce their bill. Stakeholders, particularly suppliers, should be involved early in the tariff development process, to ensure that their questions and concerns about the new tariff are being addressed. Regulators and policymakers will similarly benefit from being presented a thorough review of the issues. All of these outreach activities should be informed by the research activities described above.

Pragmatic transition requires that practical considerations be taken into account when introducing the new tariff. When consumers are exposed to a change in tariff design, some will automatically experience bill decreases and others will experience bill increases (before any change in electricity consumption patterns). A well-developed transition plan will help to gradually introduce the impacts of the tariff over time and could provide protections for vulnerable consumer segments.

We have identified seven initiatives that are relevant from a consumer perspective and could be elements of a transition to alternative distribution tariff designs. The ideas presented in this section are not intended to be a comprehensive checklist of the activities needed to transition to alternative distribution tariff designs, nor are they all necessarily prerequisites for a successful transition.[109]

PRIMARY RESEARCH

Recommendation #1: Quantify bill impacts, particularly for low-income consumers

As illustrated in this report, bill impact analysis will help to identify the consumers with bill reductions and consumers with bill increases under the new rates. In addition to addressing the overall magnitude of changes in consumer bills, this analysis is also helpful in determining other important but sometimes overlooked factors, such as month-to-month bill volatility. The analysis in this report should be considered a first step in this regard. As AMI data becomes available, it should be possible to extend the analysis to a broader and possibly more representative sample of consumers.

Recommendation #2: Assess consumer understanding of the new tariffs through market research

As discussed in Section 5, there are often concerns related to the consumer's perceived inability to understand new tariff structures. Focus groups and surveys can be used to test this hypothesis. For instance, focus groups will help to determine the relative effectiveness of different educational and marketing messages with consumers. Through survey-based conjoint analysis, the relative attractiveness of different tariff designs could be measured.

Additionally, it is possible that the complexity of new distribution tariff designs with strong price signals will be "absorbed" by suppliers rather than passed on to consumers. In this scenario, suppliers might still offer consumers opportunities to reduce their bills through various demand side response initiatives. New supplier business models along these lines could help to address the consumer understandability issue while still providing cost savings.

Recommendation #3: Assess consumer response to new tariff designs through empirical analysis

It will also be important to develop a better understanding of consumer response to new tariff designs. If consumers are able to shift load, they can reduce their bills under certain tariff structures. Well-designed pilots would offer the advantage of testing new tariff designs in a "live" but controlled setting. The pilots would be designed to mimic a full-scale rate offering. Given the potential opportunities that some of the new tariff designs will create for behind-the-meter

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[109] For discussion of additional options for a smooth tariff transition, see Jon Bird, "Smarter, fairer? A discussion paper on cost-reflectivity and socialisation of costs in domestic electricity prices," prepared for Sustainability First, March 2016. http://www.sustainabilityfirst.org.uk/images/publications/other/Sustainability_First_-_Discussion_Paper_by_Jon_Bird_-_Smarter_fairer__Cost-reflectivity_and_socialisation_in_domestic_electricity_prices_-_FINAL.pdf

demand-reducing technologies such as smart appliances and energy storage, it would be useful to include various technology offerings as treatments in the pilot.

It would be valuable to maintain a database of results as these research activities progress. Comparing and contrasting the findings of different pilot studies would provide insight about the relative impacts of tariff designs and evaluation methodologies.

Proactive Outreach

Proactive outreach will include education of consumers as well as coordination with stakeholders and regulators. It should be informed by the previously discussed research activities.

Recommendation #4: Establish an open industry dialogue on distribution tariff reform

Given the emerging industry interest in domestic distribution tariff design, it would be prudent to convene stakeholders to discuss these issues. Participants could be composed of utilities, regulators, and stakeholders. The meetings could consist of structured workshops or panel sessions including facilitated and focused discussions on key issues identified in this report. The event (or series of events) could feature case studies by utilities in other jurisdictions that are currently offering demand charges, exhibitions by technology firms on the role that new tariff designs could play in their business, and presentations on the findings of the research activities described earlier in this section. While it would be unreasonable to expect that all attendees of the meetings would leave the meetings in perfect agreement on the issues, this would be an opportunity to productively exchange ideas on what will work, what will not work, and to further identify areas of consensus and make progress on issues of disagreement.

Recommendation #5: Develop a consumer education plan

In those instances where the consumer will be exposed to the new distribution tariff design, it will be critical to also develop a consumer education and outreach plan. At each step in the rate design process, decisions about how to design the tariff would be tied back to their implications for consumer communications. Linking the two activities in this way will improve the likelihood that the tariff is designed to be acceptable to consumers.

Pragmatic Transition

Once a decision is made to move forward with a new tariff design, consideration should be given to the timing of the transition and protections for vulnerable consumer segments.

Recommendation #6: Phase in the new tariff gradually

Gradually phasing in a new tariff structure over time will help to reduce the bill impact that would otherwise be experienced by consumers and/or suppliers and will give them time to adjust to the new tariff structure. There are several options for phasing in the new tariff. Charges could be changed in increments over a multi-year period (e.g. starting with a very modest TOU price ratio and increasing it annually until the desired ratio is reached). Alternatively, bill protection (i.e., guaranteeing consumers that their bill will be no higher than it otherwise would have been on the old tariff) could be offered to all consumers. This could be done on a temporary basis and gradually phased out over time (e.g., from 100 percent bill protection in year one to 50 percent bill protection in year two to full exposure to the new tariff in year three and beyond). Or, a consumer's (or supplier's) bill could be calculated as the weighted average of their bill under the old tariff and their bill under the new tariff, with the average becoming increasingly more weighted toward the new tariff over time. Each of these options is mathematically equivalent, but may resonate differently with consumers. With careful bill impact analysis, these options could be designed to limit the largest annual bill changes experienced by any consumer to a predetermined maximum threshold level.

<u>Recommendation #7: Consider protections for vulnerable consumers</u>

With any rate transition, there is often a strong policy focus on ensuring that vulnerable consumers are not burdened with large bill increases. This could be addressed in a number of ways. For instance, an exemption from the alternative tariff could be given to the vulnerable consumer segment based on income eligibility or other criteria.[110] Rebates could be offered for enabling technology, such as a smart thermostat or a grid-enabled water heater, to help consumers manage their demand in response to the new tariff design.

There is no such thing as the "perfect" tariff design. However, with a well-planned and coordinated transition, and with consideration for the full range of tariff design criteria, there is the potential for a new distribution tariff design to provide significant improvements over the existing tariff for consumers, utilities, and their stakeholders.

[110] There are various ways that have been used to identify low income customers. For example, utilities in California have relied on self-reporting. It would alternatively be possible to establish an application process with eligibility verification based on a review of tax records or other such documents.

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