Escuela Técnica Superior de Ingeniería (ICAI)

Instituto de Investigación Tecnológica

Electricity Consumption Subsidies and Social Tariffs

A Taxonomy Based on Design Elements

Paolo Mastropietro[a]

Working Paper IIT-16-191A

Madrid, November 2016

a Assistant Researcher
Institute for Research in Technology, Comillas Pontifical University
Calle Santa Cruz de Marcenado 26, 28015 Madrid, Spain
Paolo.Mastropietro@comillas.edu
+34 91 542 2800 ext. 2740

Abstract

Despite being harshly criticised by many economic experts, electricity consumption subsidies are still widely applied, both in developing and developed countries. Many subsidies are implicitly provided by avoiding a complete pass-through of all the costs to the tariff. This kind of economic aid results in a generalised under-pricing that has limited impact on energy poverty. Other electricity subsidies are provided through explicit mechanisms, as social tariffs, which can have a higher efficiency in guaranteeing the coverage of basic energy needs. The objective of this article is to provide an all-encompassing classification of electricity consumption subsidies and then to focus on social tariffs, to identify their main design elements and to study how they affect the final outcome of the subsidy.

Keywords

Electricity subsidies; consumption subsidies; social tariff; design elements

1. Introduction

According to the International Monetary Fund (IMF, 2013), "while aimed at protecting consumers, (energy consumption) subsidies aggravate fiscal imbalances, crowd-out priority public spending, and depress private investment, including in the energy sector. Subsidies also distort resource allocation by encouraging excessive energy consumption, artificially promoting capital-intensive industries, reducing incentives for investment in renewable energy, and accelerating the depletion of natural resources. Most subsidy benefits are captured by higher-income households, reinforcing inequality". If this list of defects were not sufficiently extensive, The Economist (2014) states that drawbacks of subsidies "are huge: they distort the economy, fuel corruption, bust budgets and, perversely, benefit the rich, as big users of energy, far more than the poor. They suck money from health care and education".

Despite these not very affectionate assessments, representing the point of view of modern liberal economics, energy consumption subsidies are still widespread, especially as a mean to tackle energy poverty. They are applied not only in developing countries and transition economies,[1] where they are used to guarantee access to what is considered as a basic good, but also in developed countries, in which economic crises periodically raise the attention on energy poverty issues.[2] The rationale behind the application of energy, and more in general utility, subsidies is well explained in the seminal work by Komives et al. (2005). It is widely assumed among policy makers, especially in developing countries, that utility services are essential for the fulfilment of basic human needs, as for example cooking, space heating, and ensuring a proper hygiene. These services, it is argued, would not be affordable to a substantial segment of the population if charged at cost-recovery prices. As a result, subsidisation of those services, at least for the poor, is necessary. Furthermore, in those societies where significant poverty pockets exist, subsidies are also used as a tool for redistributing resources and increasing the purchasing power of the poorest segment of the population. Finally, subsidies owe their prevalence to social circumstances. They are widely popular among both policy makers and

[1] Social tariffs and other subsidies are widely applied in Latin America (Canese, 2012; IMF, 2015). Also China, India and Russia rely on energy and electricity subsidies (Lin and Jiang, 2011; Chattopadhyay, 2004; IEA, 2005).

[2] According to VCWG (2013), in Europe, social tariffs for vulnerable customers are applied in Belgium, France, Greece, Hungary, Italy, Portugal, and Spain. As regards only electricity consumption, in the same year, 2.7 million households benefited from social tariffs in Spain, more than 1 million households in Italy, and 8.2% of residential customers in Belgium. According to news in the media, the pool of households that benefit from the social tariff for electricity in France was recently increased to 4 million households. Furthermore, as highlighted by Miniaci et al. (2014) or Ürge-Vorsatz and Tirado Herrero (2012), energy poverty and vulnerability in Europe is in some cases exacerbated by climate change policies (as renewable energy support schemes or emission cap-and-trade) which may increase the price of electricity. Also in the United States, the Low Income Home Energy Assistance Program (LIHEAP) finances measures and initiatives at the state level to support vulnerable customers with their energy bills (Murray and Mills, 2014).

customers (and, sometimes, even among utility managers). This "alliance" of interests could make the removal of subsidies very difficult after their initial introduction.

Nevertheless, the critical assessments provided, among others, by the above-mentioned IMF (2013) and The Economist (2014) touch a sore point in identifying actual and persistent drawbacks of energy consumption subsidies. In fact, even if supported by many energy regulators and politicians, the introduction of subsidy schemes is an extremely complex regulatory process, which encompasses several different fields of policy-making, and in which it is hard to find a balance among different objectives and limitations. Some downsides are intrinsic to subsidisation itself, while other drawbacks are the result of poor designs. The main criticisms which are ventured on energy subsidies can be summarised in the three sentences presented below.

- Subsidies distort the efficient market-price signal. The price coming out from a competitive and transparent market is considered to be the best signal to assign resources in the most efficient way. If this optimal signal is distorted, by artificially and administratively reducing it through subsidies, the solution is suboptimal, because customers no longer exposed to the market price consume resources in an inefficient way. This argument is commonly used also to claim in favour of the adoption of subsidy schemes that are based on economic contributions, in the form of cash transfers, for households to be able to pay a properly-calculated bill, in opposition to mechanisms that intervene directly on the tariff (which is supposed to be calculated in a way that reflect market prices). Further details on these different designs are provided in the subsidy classification below.
- Subsidies benefit the rich more than the poor. Depending on the targeting strategy (see the classification herewith), it is possible that part of the budget of the subsidy scheme "leaks" towards high-income households, which are not supposed to benefit from these programmes.[3] In some cases, when the design is not accurate, when not completely wrong, such leakage could constitute the largest part of the budget. Targeting strategies are usually based on the concept of energy affordability, involving the calculation of the share of the household incomes that are dedicated to the procurement of energy services. Nonetheless, as mentioned in Komives et al. (2005), affordability is a subjective (and somehow "slippery") notion, and no obvious solution is available at the moment of fixing affordability thresholds. Furthermore, even when these concepts are soundly defined, data-collection limitations may force to the implementation of simpler strategies. This makes the task of correctly directing the subsidy very challenging and may lead to undesired results.
- Subsidies impede cost recovery and generate fiscal imbalances. Subsidies result in a deviation between cost and price which generates a negative economic balance. Therefore, energy subsidy schemes require proper funding to cover this unbalance. As it will be presented in

[3] This situation is usually referred to as an inclusion error, since a consumer who would not need any economic aid benefits from the social tariff; on the other hand, an exclusion error occurs when the social tariff does not reach vulnerable customers who would need it. The same terminology is used throughout the article.

the classification, different funding strategies are possible. However, many times the budget allocated to finance the subsidy is insufficient and utilities suffer financial losses. However, loss-making utilities are forced to reduce expenditures on system expansion, maintenance, or asset renewal when their budgets run short. Such cutbacks have serious long-run effects on the quality of service and on the ability of the utility to meet demand growth (Komives et al., 2005).

This article focuses on electricity consumption subsidies. Electricity is perceived as an essential good in modern societies and its provision deeply impacts the economic life of a country. For this reason, it has always been subject to a high level of governmental control, which has not decreased significantly with the change of paradigm that resulted in electricity markets. Governments and regulators apply a variety of interventions and rules that are not always referred to as subsidies, but which aim at limiting the price at which electricity is supplied. The first objective of this article, pursued in section 2, is to provide an all-encompassing classification of electricity subsidies[4] that embraces not only explicit but also indirect and implicit aids to power consumption. After presenting such taxonomy, the article narrows its analysis to social tariffs, which are one of the most widespread explicit subsidy methodologies that power sector regulators have been using. The design elements that compound such tariffs are identified and studied in detail in section 3, with the objective of assessing their impact on the effectiveness of the subsidy mechanism. Finally, section 4 presents some conclusions and summarises the main outcomes. The main objective of this article is to shed a light on how to avoid the three main drawbacks of subsidies listed above and enhance the design of social tariffs and electricity consumption subsidies in general.

2. A classification of electricity consumption subsidies

A broad variety of electricity subsidy designs has been implemented worldwide. Actually, if the word "subsidy" is used in a more general way, i.e., as any deviation from the cost-reflective price, it is possible to state that almost no power system is completely free of some form of subsidisation.[5] The taxonomy proposed in this section identifies several dichotomies in the subsidy design, which reflect the decisions that the regulator has to take when introducing

[4] In this introduction, as well as in the classification below and the rest of this document, the attention is focused on consumption subsidies, as opposed to connection subsidies. As explained in Komives et al. (2005), consumption subsidies help make service less expensive to existing utility customers on a continuing basis, while connection subsidies are one-time subsidies that reduce or eliminate the price that customers pay to connect to the system. Connection subsidies are not analysed in this paper. Another disclaimer that this article needs regards the fact that it is focused on electricity subsidies targeting energy poverty or poverty issues in general, therefore mainly directed to residential customers. Electricity consumption subsidies to industrial users, provided as state aid to increase competitiveness in the international market, are out of the scope of this paper.

[5] This statement is justified, for example, whenever a flat tariff is in place. In fact, power to be produced during peak consumption periods generates higher costs than the same electricity to be produced during off-peak periods. If no time differentiation is applied to the tariff, this deviation automatically translates into a cross-subsidy from off-peak to peak consumers.

these mechanisms. These dichotomies, summarised in Table i, are used hereunder to provide a classification on several levels, and to present a first outline of advantages and disadvantages of each option.

Table i. A possible and generic taxonomy of electricity subsidies

<table>
<tr><td rowspan="2">Direct vs. indirect</td><td colspan="3">Direct subsidies</td><td colspan="2">Indirect subsidies</td></tr>
<tr><td colspan="3">Provided directly to the consumer, thus acting on electricity prices</td><td colspan="2">Provided through economic incentives to power utilities, thus acting on the costs behind electricity prices</td></tr>
<tr><td rowspan="2">Explicit vs. implicit</td><td colspan="3">Explicit subsidies</td><td colspan="2">Implicit subsidies</td></tr>
<tr><td colspan="3">Entail a proper calculation of the cost-reflective electricity price, followed by a later application of discounts on such price</td><td colspan="2">Consist in measures that impede the pass-through of real costs to tariff, resulting in a general under-pricing of the electric product</td></tr>
<tr><td rowspan="4">Targeting strategy</td><td colspan="3">Targeted subsidies</td><td colspan="2">Untargeted subsidies</td></tr>
<tr><td colspan="3">Apply an explicit targeting strategy in order to properly identify the beneficiaries of the subsidy</td><td colspan="2" rowspan="3">Provide a subsidy to all electricity consumers, or to a very broad part of them (e.g., all residential customers), without trying to differentiate among their needs</td></tr>
<tr><td>Administrative targeting</td><td colspan="2">Self-targeting</td></tr>
<tr><td>The regulator defines a set of rules for the selection of subsidy beneficiaries</td><td colspan="2">Assigned according to the customer's consumption behaviour (e.g., quantity-targeting)</td></tr>
<tr><td rowspan="2">Funding strategy</td><td colspan="2">State budget funding</td><td colspan="2">Cross-subsidies</td><td>Unfunded subsidies</td></tr>
<tr><td colspan="2">Incorporation of subsidy scheme costs into state budget</td><td colspan="2">Subsidies are covered through surcharges applied to the tariff of other system users</td><td>Structural lack of financing, resulting from either wrong estimations or explicit regulatory choices, eroding private capital</td></tr>
<tr><td rowspan="2">Provision methodology</td><td colspan="3">Transfer in kind</td><td colspan="2">Transfer in cash</td></tr>
<tr><td colspan="3">Discounts on electricity tariffs, with beneficiaries paying a price lower than the standard price for the tariff group they belong to</td><td colspan="2">Direct transfer of money from the state to the consumer, supporting the household in the payment of electricity bills</td></tr>
</table>

2.1 Direct vs. indirect

The first distinction that can be made is between direct and indirect subsidies. Being the customer the final target of electricity consumption subsidies, it is possible to define as direct any subsidy that is provided directly to the consumer, thus acting on electricity prices, in opposition to indirect subsidies, which act on the costs behind the price by providing power utilities with economic incentives. Examples of indirect subsidies are countless: provision of fossil fuels at prices below the market price, through either a regulated price on a domestic resource or other incentives on fuel imports; tax exemptions or soft loans on investments or expenditures related with power sector activities; grants for the installation of certain components of the power system. Specific indirect subsidies may appear when large state-owned companies are still in the market after the liberalisation of the power sector. These companies may be allowed by their main shareholder, i.e., the government representing the state, to apply below-market interest rates in their project financing, therefore reducing their cost of capital. Sometimes, public companies are also allowed to incur significant financial losses, without taking countermeasures (up to closure) that would be taken by a private company in the same situation, supposing that at some moment the state will cover the unbalance.

All these interventions reduce either investment or operation costs of companies in charge of supplying power and have the objective of decreasing the final electricity price paid by consumers. Depending on the kind of incentive provided to the utility, indirect subsidies could benefit all electricity consumers or only a part of them. As already identified by Komives et al. (2005), the main disadvantage of indirect subsidies is represented by the risk that the economic incentive provided to the utility is absorbed in the form of inefficiency and fails to "filter" through in the form of lower prices. In fact, any of the above-mentioned measures somehow provide utility managers with soft budget constraints, which reduce the incentive to manage resources efficiently.

On the other hand, direct subsidies are applied on the electricity price and they are, in principle, more efficient in targeting the desired beneficiaries. They can assume several forms, presented through the following dichotomies.

2.2 Explicit vs. implicit

The second distinction is between explicit and implicit subsidies. While the former entail a proper calculation of the cost-reflective electricity price, followed by a later application of discounts on such price, the latter consist in measures that impede the pass-through of real costs to tariff, resulting in a general under-pricing of the electric product. The definition of implicit subsidy intertwines somehow with that of indirect subsidy. Herewith they are distinguished, since indirect subsidies reduce the price by reducing the upstream cost, while implicit subsidies reduce the price by acting on the price calculation process.[6] Implicit

[6] An analysis of international experiences exceeds the scope of this article; however, examples of indirect and implicit subsidies can be found in IMF (2015), for the Latin American and the Caribbean context.

subsidies are commonly embedded in the tariff design process, especially in those power sector regulations which still consider the calculation of a default tariff to be charged to captive demand. Default tariffs should be calculated as the addition of all the costs incurred through the power supply chain. However, in many cases the regulator intervenes in this calculation, decoupling the tariff from real costs. This has been the subject of many controversies between the regulator and generation companies in the Latin American context (Chile and Peru above all), due to the fact that the default tariff calculation process failed in reflecting sustained growths in the spot market price (Maurer and Barroso, 2011). Another form of this kind of implicit subsidy takes place when a state-owned company agrees on supplying electricity to the regulated demand at a below-market price, either through a bilateral contract or by underbidding in a long-term auction. Also this kind of situation results in lower generation costs to be passed through to demand. All these interventions provoke a general under-pricing, which is commonly not targetable among users, and which may undermine cost recovery.

Other forms of implicit subsidies are related with poor cost-reflective allocation when designing the tariff. Whenever prices charged to each customer fail to properly reflect the costs generated for supplying that customer, a cross-subsidy takes place. Some boundaries should be applied to this reasoning, because, due to the intrinsic complexity of the power system, a perfect cost causality is actually not achievable in practice (Reneses et al., 2013). However, some designs oversimplify several aspects, creating significant cross-subsidies among consumers. The main examples are related with the lack of time- and/or space-differentiation in the electricity tariff. In the former case, users consuming more during off-peak periods subsidise the consumption of users withdrawing more electricity during peak loads. In the latter case, the application of a single-node price generates a subsidy flowing from users located in low-price nodes to users located in high-price nodes. A special instance of this kind of subsidies occurs when no metering is in place and electricity theft is tolerated. This situation obviously creates a cross-subsidy from properly metered users to consumers with illegal connections (or an unfunded subsidy, if commercial losses are not recognised).

Finally, a last type of implicit subsidy is to be found in tax exemptions applied to the tariff. Electricity, in theory, should be subject to the same taxation framework as any other product. Commonly, electricity retail sales are applied a Value-Added Tax (VAT). However, if a total exemption is provided, or if different levy rates are applied to different user categories, the power consumption benefits from a subsidy.

On the other hand, explicit subsidies consider a proper calculation of electricity prices, preferably applying time- and space-differentiation, followed by the application of a set of discounts which explicitly reduce the price to be paid by certain customers. As explained through the following dichotomies, explicit subsidies are better targetable and, in principle, less distortive than a general under-pricing obtained through implicit subsidies.

2.3 Targeted vs. untargeted

The third distinction that can be made is between targeted and untargeted subsidies. Untargeted schemes provide a subsidy to all electricity consumers, or to a very broad part of them (e.g., all residential customers), without trying to differentiate among their needs. Most of indirect and implicit subsidies result in untargeted mechanisms, even if exceptions are possible. These schemes may be easier to implement, but they usually present a lower benefit for low-income electricity consumers and imply large inclusion errors.

On the other hand, targeted schemes apply an explicit targeting strategy in order to properly identify the beneficiaries of the subsidy. Several strategies are possible, but two main categories can be identified.

- Administrative targeting, in which the regulator defines a set of rules for the selection of subsidy beneficiaries. These rules can encompass different aspects. Group targeting identifies broad user categories whose consumption is to be subsidised, as all customers with a certain contracted capacity, all pensioners, and so forth. Geographic targeting designates beneficiaries according to their location in the network, the targeted area being a certain region of a country, or a certain block within a city. Finally, socioeconomic targeting utilises a set of socioeconomic indicators to identify consumers who actually need a subsidy through a so-called means-testing strategy. Indicators commonly used are, among others, household income, household size (number of people), or affiliation to a social security programme.

- Self-targeting, in which the involvement in the subsidy scheme depends on the customer, through her consumption behaviour, based on some threshold set by the regulator. The main example of self-targeting is quantity targeting, in which different prices are charged to different blocks of consumption of the same customer, the threshold being the boundary between two successive blocks. Also within quantity targeting, a differentiation is required (nomenclature from Komives et al., 2005).

  - Increasing Block Tariff (or IBT), i.e., a stepped tariff in which an increasing price per unit is charged for different blocks of consumptions. Commonly, two- or three-block IBTs are used.

  - Volume-Differentiated Tariff (or VDT), which takes the form of two different tariffs, of which only one is applied to the entire consumption, depending on the consumption level. It is also referred to as "disappearing first block" tariff.

These targeting strategies are not incompatible and complex targeting mechanisms, applying several strategies at the same time, could be used. However, it must be understood that targeting is not for free. An ideally optimal targeting strategy would allow the subsidy to reach only the beneficiaries previously identified by the regulator (e.g., the energy poor); however, the economic cost of such strategy may get close the cost of the subsidy scheme itself. A complex targeting represents a significant administrative burden, which, in those contexts where there is a structural lack of public administration resources, may result unfeasible. Despite this, targeted mechanisms have several advantages, most of them already mentioned in this document (lower subsidy budget; greater impact on poor households; fewer distortions in consumption behaviours), which usually offset their costs.

Furthermore, it must be highlighted that, if energy poverty is the real target of the subsidy scheme, the definition of targeted/untargeted changes and the only actual targeted mechanism becomes the one that aims at identifying the energy poor. Such a mechanism would then have to use some kind of socioeconomic indicator, probably in conjunction with other targeting strategies, linked to the consumption quantity. Several subsidy schemes tend to identify the energy poor based only on quantity targeting, assuming that providing a lower price for the first block of consumption benefits low-income households, which usually have also lower consumption levels than high-income ones. Nonetheless, these strategies are subject to significant leakages of subsidy budget towards non-poor customers (Foster and Yepes, 2006).

2.4 Funding strategy

A further distinction can be made according to the funding strategy. Any subsidy scheme needs financing to cover the economic unbalance that lower revenues from subsidised beneficiaries generate. Three main strategies may be identified: state budget funding, cross-subsidies, and no funding at all. The first strategy is based on the inclusion of the expenses related to subsidy schemes into the state budget, commonly through direct transfers to the entity in charge of covering the economic unbalance. Most of indirect subsidies, which provide utilities with grants, soft loans, or under-priced fuels to reduce electricity costs, are usually covered by the state budget. The same is true for tax exemptions and, somehow, for subsidies provided at expenses of state-owned utilities. However, also explicit subsidies may be covered by state budget, as in the case of explicit discounts in the tariff, when the beneficiary pays part of the price and the remainder is paid to the utility by the state.

Another funding strategy is based on cross-subsidies, in which the economic unbalance generated by the subsidy is covered through surcharges applied to the tariff of other system users. The application of cross-subsidies eventually results in a flow of economic resources from a group of users to another, implying wealth redistribution among consumers. Several different "flow" directions are possible, most of them already mentioned above: from industrial to residential customers; from high-income to low-income households; from high-volume to low-volume consumers; from off-peak to peak consumers; from metered to unmetered users. The main advantage of cross-subsidies, as correctly identified by Komives et al. (2005), is that, in theory, they can guarantee both cost-recovery for the utility and the concession of a subsidy to those who need it, without relying on central government transfers. This is a feature that could be of central importance when the financial situation of the state is not sound. Nonetheless, finding a balance between the subsidy and the surcharge is an extremely challenging task, which may easily result in an underestimation of the costs of the mechanism, with the utility not being able to recover the revenue lost due to subsidy provision. Furthermore, the implementation of cross-subsidies could also affect the consumption behaviour of users. When two groups are defined based on certain rules, one of subsidy beneficiaries and one of cross-subsidisers, some users may act on their electricity consumption (or on other aspects) in order to move from the latter to the former group. This shrinks the pool of customers paying surcharges, thus requiring an increase in the surcharge itself, and this can potentially result in a vicious cycle that may jeopardise the feasibility of the mechanism (a detailed discussion regarding social tariffs based on cross-subsidies is presented in section 3.4).

The third funding strategy is represented by unfunded subsidies. In some cases, subsidy mechanisms may suffer a structural lack of financing. Such situation may be the result, for instance, of a poor design of a cross-subsidy scheme, in which a balance between the subsidy and the surcharge is not reached, generating net financial losses for the utility. Unfunded subsidies may also be the outcome of a generic underestimation of the costs of the mechanism, or of a decision by the regulator to run a subsidy scheme at expense of private capital. Many of the examples of implicit subsidies provided above are usually affected by this lack of financing. The latter erodes revenues of usually private companies, resulting in loss-making utilities, with the impact already mentioned in the previous subsection (lack of new investments for system expansion, reduced asset renewal and maintenance, and lower quality of service, among others).

Within the funding strategy, another distinction can be made between capped and uncapped subsidy budget. If the budget available to subsidise electricity consumption is administratively capped, the discount provided or the pool of consumers entitled to benefit from lower tariffs are limited by the funding assigned to the mechanism. This approach has the advantage of making the budget predictable, but it may not be able to completely avoid energy poverty conditions. On the other hand, if the budget is uncapped, rules governing the subsidy scheme are defined without setting funding limits, and the budget necessary to cover costs is calculated and allocated periodically.

2.5 Provision methodology

Finally, the last distinction refers to the subsidy provision methodology, the two main approaches being transfer in kind and transfer in cash. Cash transfers, in the power sector environment, represent a direct transfer of money from the state to the consumer, in the form of periodic cheques, with the objective of supporting the household in the payment of electricity bills. The amount of cash transfers is calculated in order to cover, either totally or partially, the cost of a certain level of electricity consumption considered as basic by the regulator. On the other hand, transfers in kind are a social redistribution tool consisting of the provision of a good or service at a price below the market price to a certain group of users. In the power sector, this means discounts on electricity tariffs, with subsidy beneficiaries paying a price lower than the standard price for the specific tariff group they belong to.

Transfers in cash present several theoretical advantages, highlighted in the social welfare literature. They allow the beneficiary to allocate the additional household income to the procurement of goods or services that are given higher priority; moreover, they do not distort the efficient signal provided by the market price, to which beneficiaries are still exposed, thus avoiding a suboptimal exploitation of resources. Nevertheless, transfers in cash require a complex administrative organisation in charge of managing the scheme, which could result in high implementation costs and could be subject to abuse. Cash transfers are applied to electricity subsidies, especially in developed countries with a sound administrative organisation, usually encompassed in broader social programmes. Nonetheless, transfers in kind are by far the most widespread subsidy provision methodology in the power sector, in the form of what is usually called a social tariff, a mechanism analysed in detail in the next section.

In order to conclude this taxonomy, it must be underlined that the different kinds of subsidies presented in this section are not always unable to coexist among them. Several subsidy frameworks are based on a combination of mechanisms. For example, implicit subsidies, resulting in a general under-pricing that benefits most of the users, may be complemented by explicit schemes, as social tariffs, that provide further discounts to a specific group of consumers.

3. Design elements of social electricity tariffs

According to the classification provided so far, social tariffs are a direct, explicit, and commonly targeted subsidy mechanism, funded either through state budget or by means of cross-subsidies. Their main design elements are the consumption level and number of consumption blocks for which they provide lower prices, the discounts applied to such consumption, the presence of additional requirements for the enrolment to it, i.e., the administrative targeting, and the kind of funding strategy on which they are based. Different combinations of these few factors gave birth to a broad variety of social tariff designs, with extremely different outcomes in terms of efficiency. Only a very careful definition of these design elements can guarantee the effectiveness of the mechanism in achieving its target and avoiding energy poverty situations. This section focuses on these detailed design issues, analysing how they affect the final outcome of the subsidy scheme.

3.1 Consumption level

The overall objective of a social tariff targeting energy poverty is to guarantee the coverage of the basic electricity needs of a certain segment of the population. This implies the definition of a consumption level that reflects such basic needs, a value beyond which consumption is no longer to be considered as basic and must be paid by the user. Apart from this more theoretical driver, the determination of a maximum consumption level eligible for subsidisation is also used for other goals: it allows a better targeting of the social tariff mechanism, through what has been referred to as quantity targeting; it permits to better manage the subsidy budget, since, together with the administrative targeting that limits the pool of consumers eligible for the social tariff, it sets a cap to the cost of the mechanism; it eliminates the incentive for perverse behaviours that may be perceived by some users, who, being eligible for a social tariff with high discounts, are not exposed anymore to the efficient price signal that limits their consumption.[7]

Quantity thresholds may be theoretically applied to each cost driver of the electric tariff, thus both to energy withdrawn and contracted (or maximum) capacity. Nonetheless, they are almost always applied only to energy consumptions. This is also due to the fact that, in many power systems where social tariffs are available, electricity is usually charged to most of residential customers through a volumetric tariff that only considers an energy component.

[7] Perverse behaviours can go beyond this. If no consumption limit is defined, social-tariff beneficiaries may be tempted to "resell" their low-cost electricity, by, for example, installing in their household appliances that actually belong and are exploited by a third party.

Consumption thresholds are commonly expressed as kWh per billing period, thus one or two months.

How should such consumption level eligible for the social tariff be defined? The concept of basic need is vague and open to many different interpretations and this is even truer when electricity is considered. Basic power consumption may vary enormously from one country or region to another. Some services considered as essential in one power system may not be perceived as such in another, either because they can be substituted through another energy source or because they are not widespread among the population. However, it is still possible for the regulator to define a sample household and to simulate its load profile during a sample billing period in order to calculate a basic consumption. The subsidy may then be conceded only to such quantity, since any consumption exceeding such level would entail an electricity usage that goes beyond basic needs.

However, if the subsidy conveyed by the social tariff is applied mainly to redistribute wealth among the population, different methodologies can be used to set the consumption threshold. Wealth distribution is commonly measured in terms of percentiles, which allow to know which percentage of the overall wealth (measured in terms of incomes or capital) is captured, for instance, by the richest 1%, or by the poorest 10%. The same statistical analysis can be carried out for the distribution of electricity consumptions among households and, if disaggregated information is available for wealth and consumption for each household (or for a representative sample of households), a correlation between the two data can be determined. Therefore, the regulator would be able to identify the average (or the marginal) consumption of the poorest 10% or 20% households and to establish such value as the maximum electricity consumption eligible for the social tariff.

This kind of statistical analyses are time-consuming and, depending on the data initially available, may need a significant budget. However, as clearly stated by Komives et al. (2009), detailed information about electricity consumption among the poor is an asset for the calibration of the subsidy.

Threshold differentiation

Should the threshold be unique for all consumers or different thresholds should be set to reflect differences in social tariff beneficiaries? There are several factors that could potentially drive the definition of different thresholds, especially if the concept of basic need inspires the selection of the consumption level. The basic needs of a family may vary depending on the number of members[8] that it has; the larger the family, the higher its basic electricity needs, although the proportionality is not linear (Longhi, 2015). Another more specific example can be found in households dwelled by persons who, for medical reasons, rely on apparatuses

[8] What is being discussed here is the possibility of having different consumption thresholds depending on the family members, not the application of the latter as an administrative targeting strategy, as when a family is entitled to benefit from the social tariff if its members are more than a predefined value (see subsection 3.2).

connected to the electric grid for their well-being; the consumption of such medical appliances may be considered as a basic need.

However, the most widespread threshold discrimination regards the space- and time-differentiation of the consumption level. In many power systems, the regulator recognises that different consumption behaviours take place in certain areas of the network. Therefore she decides to establish different thresholds in such areas. A typical example can be found in those countries that, due to climatic reasons, consider air conditioning and ventilation as basic needs; in these contexts, warmer zones may be entitled higher consumption thresholds if compared to colder zones (a common approach in Latin America). The same reasoning can be applied to the time-discrimination of the threshold, when different consumption levels are expected at different times of the year. Following the air conditioning and ventilation example, a consumption level eligible for the social tariff may be set for summer months, which is then turned to zero for winter months, during which such basic need disappears.

Number of consumption blocks

Another possible design of the social tariff entails the definition of different thresholds, not for different users, but for the consumption of the same customer. In this case, several consumption blocks appears (usually two to four) and it is then possible to set a different discount for each one of them, obviously applying the highest discount to the first block and then gradually reducing it down to zero (or to negative values, if cross-subsidies are introduced to finance the social tariff mechanism).

From a theoretical point of view, if an efficient administrative targeting is applied, there is no need to consider several consumption blocks. Once a consumption threshold and a discount have been defined considering basic electricity needs and the purchasing power of beneficiaries, no further complication should be required. The administrative targeting would then limit the application of the discount only to those users recognised as energy poor. Nonetheless, in many social tariff designs in which the application of administrative targeting is absent or very limited, different consumption blocks may be used to refine the quantity targeting and to reduce inclusion errors. However, this approach represents, at least theoretically, a second-best solution; only a proper administrative targeting can avoid as much as possible inclusion (and exclusion) errors.

Increasing Block Tariff vs. Volume-Differentiated Tariff

The distinction between IBT and VDT was already described in section 2.2. In social tariff design, an IBT charges the discounted price to the targeted user up to the consumption threshold, regardless of the total consumption level; on the contrary, a VDT provides the discount if and only if the consumption is below the threshold.[9] The main advantage of the VDT design is the fact that it limits potential inclusion errors. When the social tariff lacks a

[9] For instance, if the consumption threshold is set at 100 kWh/month and the user's consumption is 110 kWh, IBT would charge the discounted price for the first 100 kWh and the standard price for the remaining 10 kWh, while VDT would charge the standard price to the entire 110-kWh consumption, since the threshold has been exceeded.

proper administrative targeting, an IBT design would apply a generalised discount to all consumers for the first block of consumption; therefore, the discount would reach many consumers who do not actually need it, thus generating an inclusion error. A volume-differentiated tariff avoids such undesired effect. However, it may generate an exclusion error, if a low-income household exceeds the threshold (either occasionally or repeatedly, due to the application of an improper threshold) and is charged the standard price for its entire consumption. Once again, the first-best solution is to apply an effective administrative targeting, as analysed in the following subsection.

3.2 Administrative targeting

According to Komives et al. (2007), subsidy schemes based only on quantity targeting are highly regressive and their benefits accrue to the non-poor. Administrative targeting introduces further requirements that must be fulfilled in order to benefit from the social tariff and improve the targeting performance. Such requirements may consider different aspects, but, especially in the case of social tariffs, most of the times they aim at identifying the economic vulnerability[10] of electricity consumers, through a means-testing strategy. If the affordability principle is applied rigorously, the social tariff should be made available to all families who are below the poverty threshold or would go below it if they had to pay for the standard price of electricity.[11] This approach would require a huge amount of information and a household-by-household analysis which is unfortunately unfeasible most of the times. For this reason, administrative targeting usually aims at identifying households that, for socioeconomic reasons, are "more likely" to be in need of support to pay the electricity bill. It must be remarked, however, that this approach favours somehow the economic redistribution goal of social tariffs over the coverage of basic needs.

The parameter most commonly used to assess the wealth of a household is the family income. The latter can be analysed in absolute terms or can be expressed as income per capita, thus internalising the number of family members and favouring larger families. In both cases, a reference value is set and only households below that reference are considered eligible for the social tariff. The reference value may be linked to the minimum wage in force in the country, if any.

Another solution, always based on the household income, but entailing the concept of affordability, is to apply simulation models in order to calculate the percentage of household

[10] The author shares the opinion expressed, among others, by Pye et al. (2015), who argued that energy vulnerability and energy poverty are two linked yet distinctive issues, especially in the European context, which should be addresses through different measures. Here and in the rest of the paper, vulnerability is used in its more generic sense and restricted to the economic field, but the focus is on measures targeting energy (or electricity) poverty. For tentative definitions of customer vulnerability and energy poverty, see VCWG (2013, 2016).

[11] Thus, if income minus electricity bill without discounts is below the poverty threshold. The latter is a socioeconomic indicator that is calculated differently in different parts of the world, and which is usually subdivided between the concepts of absolute and relative poverty. Methodologies to determine the poverty threshold exceed the scope of this article.

expenditure on electricity products. If such percentage expenditure exceeds a reference percentage (e.g., 5%),[12] the household is considered as energy poor.

In other systems, household wealth is not measured through the income, but rather through aspects used as proxies of it. A possible example is an administrative targeting based on the characteristics of the dwelling, which are used as a proxy of the household incomes (usually the analysis is done block by block). Neighbourhoods considered as potentially vulnerable can then benefit from the social tariff. This approach, however, although easier to implement, may result in significant inclusion and exclusion errors, due to the lack of a scientific correlation between wealth distribution and neighbourhood characterisation.

A further strategy to address the subsidy only to economic vulnerable consumers is to rely on social security programmes already available in the country. Households that are already affiliated to this kind of programmes may be considered eligible also for the social tariff. This approach has the advantage of exploiting the targeting mechanism of the existing social security programme, which is usually more robust and more accurately applied than targeting schemes used exclusively for allocating the electricity social tariff. However, if the social programme targeting is not that robust or is very restrictive in the identification of vulnerable conditions, exclusion errors are possible.

Finally, social tariffs may also be assigned regardless of the wealth of the household. In some countries, discounts on the electricity bill are provided to large families, for instance with more than two or three children, without any assessment on the household incomes. If the economic vulnerability principle is followed, this targeting may obviously entail huge inclusion errors, since there are many large families which are also wealthy enough to pay for their electric bills. Actually, such administrative targeting gives raise more to an incentive aiming at improving the birth rate of a country than to a social tariff in strict sense.

Exclusion rules

An administrative targeting may also consider some exclusion rules, which identify a set of conditions that are deemed to be incompatible with the assignation of the social tariff. A great inclusion error takes place, for instance, when secondary residences, as a dwelling used few months per year for holyday purposes, can benefit from the social tariff simply due to their relatively low consumptions. An exclusion rule penalising second homes helps avoid such inclusion errors.

[12] A 10%-threshold (including all kinds of energy products) was applied, for instance, in the United Kingdom to identify fuel poverty, before the Low Income High Costs indicator was introduced (Hills, 2012; DECC, 2015). However, such percentage should be tailored to the specific conditions found in each country. EC (2010) proposes to set such threshold twice as high as the national average for that ratio (e.g., if in a country the average expenditure on electricity is 3% of the household income, then a household is electricity poor if it spends more than 6% of its income in electricity bills). Trinomics (2016) recommends also a third approach, focused on hidden energy poverty, which includes households whose energy expenditure is below half the national median.

Other exclusion rules may refine the administrative targeting if the latter uses only the income as an indicator of wealth. In fact, wealth is actually the sum of capital plus incomes and a family with low incomes may still be very wealthy if it relies on a very large capital. Exclusion rules on capital assets (as possession of more than one dwelling, possession of luxury items, etc.) may avoid inclusion errors. However, it must be remarked that very few country administrations have detailed information about capitals of their citizens, thus such exclusion rules may be very difficult to apply.

3.3 Discounts provided

Once the pool of beneficiaries is identified, the regulator must decide the level of economic aid to be provided and how to deliver it through the social tariff. As regards the latter point, it must be decided first which tariff components must be subject to a discount. Due to the widespread application, especially among residential customers, of volumetric tariffs that only consider an energy component, a discount on the energy price seems to be the most obvious solution and it is definitely the most common approach. However, in power systems that rely on electricity tariffs considering also a capacity component, the latter may be significant and the capacity charge can actually be higher than the energy charge. In these cases, discounting only energy is not sufficient and social tariffs directly provide a discount on the final bill.

Discounts are almost always expressed as a percentage reduction of the standard price or charge calculated for the specific tariff group which the consumer belongs to. This usually reflects the need not to completely remove the efficient signal provided by the price, as it would be the case if the discount were provided as a subtractive term.[13] As regards the level of discount to be provided, no obvious solution is available. If the administrative targeting is applied based on a proper statistical analysis, the latter can be exploited to assess the purchasing power of electric consumers. The average consumption of social tariff beneficiaries can be multiplied by the standard tariff, with no discount, in order to calculate an average electricity bill. Such bill can be compared with the average beneficiary household income so as to calculate an average expenditure on electricity products. A socioeconomic study permits to assess whether the average electricity-bill/household-income rate is adequate or it must be limited to a certain value. In the latter case, the discount can be set at a level that allows to achieve such rate cap, thus filling the so-called “poverty gap”.

Nonetheless, most of the times, either for the sake of simplicity or because the redistribution objective prevails over the basic need coverage, discounts are established without being backed up by a sound socioeconomic analysis. In some cases, the discount is defined according to the budget available for subsidy scheme. In other cases, it is simply set as an estimation of a cost reduction factor that may help low-income households pay their bill.

Finally, if the quantity targeting strategy is based on different consumption blocks, a discount factor must be set for each block. The same applies to social tariff designs in which the

[13] If the social tariff would pay for a certain first block of expense, there would be no incentive for the beneficiary to reduce its consumption below the load that results in such expense.

administrative targeting discriminates among beneficiaries, identifying different groups with different needs of economic aid.

3.4 Funding strategy

In terms of funding strategy, many of the conclusions drawn in section 2.4 about the financing of consumption subsidy schemes in general can be applied also to social tariffs. The three options available are also in this case: i) unfunded social tariffs, ii) state budget, and iii) cross-subsidies.

The first option, no funding at all, is very detrimental for the power sector, since it hampers cost-recovery and generates loss-making utilities, thus impeding new investments, with the associated risk of a reduced service quality. Nonetheless, it is still widely applied in those contexts where, either for inaccuracies in the calculation of the budget or due to a clear regulatory decision, the economic effort of financing the social tariff is left to power sector companies. Even if this approach is easier to be found in conjunction with indirect or implicit subsidies, there are also a few social tariff schemes that explicitly (and surprisingly) mandate private companies active in the electricity market to finance the subsidy mechanism.

If the coverage of basic energy needs or the redistribution of wealth are considered as objectives of the state as a whole more than limited to the power sector, funding the social tariff through the state budget appears to be the best option. Discounts to social tariff beneficiaries are then covered by all citizens through general taxes. This solution improves the stability of the power sector, but it requires countries to have a sound financial situation to support the economic burden.

The last option, cross-subsidies, is popular among regulators, since it limits the financial settlement of the social tariff to the power sector. Besides beneficiaries, different groups of contributors are identified, who, instead of receiving a discount on their energy consumption, are subject to a surcharge within the social tariff scheme. However, this funding strategy must be used carefully if the social tariff is oriented only through self-targeting (as a pure quantity targeting). In fact, the combination of cross-subsidies and self-targeting may result in strategic behaviours from consumers, with contributors modifying their consumption pattern in order not to be included in the group that pays for the subsidy, or even trying to become beneficiaries. Cross-subsidies should be used only in conjunction with a robust administrative targeting which impedes any opportunistic conduct.

4. Conclusions and policy implications

In his foresighted analysis of power markets in Latin America, Millán (2007) stated that the main challenge with electricity subsidies is to decouple opportunistic governmental interventions on electricity prices from strategies that aim at guaranteeing the need of the poor. Such a statement is definitively shareable and it can be extended far beyond the Latin American context. Electricity subsidies are widely applied all over the world, sometimes in the form of explicit mechanisms, as social tariffs, but many times as implicit and hidden interventions on the complex process that results in the definition of electricity tariffs.

This article contributes to the existing literature on the topic by first providing an all-encompassing classification that spans from indirect and implicit economic aid to explicit subsidy schemes. After that, the paper focuses on social electricity tariffs and identifies the main design elements of these regulatory tools, drawing theoretical recommendations on the selection of the consumption level, the administrative targeting approach, the discounts to be provided, and the funding strategy.

5. References

Canese, M., 2013. La tarifa social de la energía en América Latina y Caribe. OLADE research document, released in March 2013.

Chattopadhyay, P., 2004. Cross-Subsidy in Electricity Tariffs: Evidence from India. Energy Policy, vol. 32, iss. 5, pp. 673-684.

DECC, Department of Energy and Climate Change, 2015. Annual Fuel Poverty Statistics Report 2015.

EC, European Commission, 2010. An Energy Policy for Consumers. Commission staff working paper SEC(2010) 1407 final, released on 11 November 2010.

(The) Economist, 2014. Energy Subsidies – Price Squeeze. Article released on the issue published on June 14 2014.

Foster, V., Yepes, T., 2006. Is Cost Recovery a Feasible Objective for Water and Electricity? The Latin American experience. World Bank policy research working paper 3943, released in June 2006.

Hills, J., 2012. Getting the Measure of Fuel Poverty. Final report of the Fuel Poverty Review, CASE report 72, released in March 2012.

Komives, K., Johnson, T. M., Halpern, J. D., Aburto, J. L., Scott, J. R., 2009. Residential Electricity Subsidies in Mexico: Exploring Options for Reform and for Enhancing the Impact on the Poor. World Bank working paper no. 160. ISBN 978-0-8213-7884-7.

Komives, K., Halpern, J., Foster, V., Wodon, Q., Abdullah, R., 2007. Utility Subsidies as Social Transfers: An Empirical Evaluation of Targeting Performance. Development Policy Review, vol. 25, iss. 6, pp. 659-679.

Komives, K., Foster, V., Halpern, J., Wodon, Q., 2005. Water, Electricity, and the Poor: Who Benefits from Utility Subsidies? Book in the World Bank Publications series. ISBN 978-0-8213-6342-3.

IEA, International Energy Agency, 2005. Russian Electricity Reform: Emerging Challenges and Opportunities. OECD/IEA working paper.

IMF, International Monetary Fund, 2015. Energy Subsidies in Latin America and the Caribbean: Stocktaking and Policy Challenges. IMF working paper released in February 2015.

IMF, International Monetary Fund, 2013. Energy Subsidies Reform: Lessons and Implications. Executive summary of the book with the same title (ISBN 978-1-47555-811-1), released on January 28 2013.

Lin, B., Jiang, Z., 2011. Estimates of Energy Subsidies in China and Impact of Energy Subsidy Reform. Energy Economics, vol.33, iss.2, pp. 273-283, ISSN 0140-9883.

Longhi, S., 2015. Residential Energy Expenditures and the Relevance of Changes in Household Circumstances. Energy Economics, vol. 49, pp. 440-450, ISSN 0140-9883.

Maurer, L., Barroso, L., 2011. Electricity Auctions: An Overview of Efficient Practices. Book published by the World Bank. ISBN 978-0-8213-8822-8.

Millán, J., 2007. Market or state? Three Decades of Reform in the Latin American Electric Power Industry. Book published by the Inter-American Development Bank. ISBN 978-1-59782-055-4.

Miniaci, R., Scarpa, C., Valbonesi, P., 2014. Energy Affordability and the Benefits System in Italy. Energy Policy, vol. 75, pp. 289-300, ISSN 0301-4215.

Murray, A. G., Mills, B. F., 2014. The Impact of Low-Income Home Energy Assistance Program Participation on Household Energy Insecurity. Contemporary Economic Policy, vol. 32, iss. 4, pp. 811-825, ISSN 1465-7287.

Pye, S., Dobbins, A., Baffert, C., Brajkovic, J., Grgurev, I., De Miglio, R., Deane, P., 2015. Energy Poverty and Vulnerable Consumers in the Energy Sector across the EU: Analysis of Policies and Measures. INSIGHT_E policy report, released in May 2015.

Reneses, J., Rodríguez, M. P., Pérez-Arriaga, I. J., 2013. Electricity Tariffs. Chapter of *Regulation of the Power Sector*, 2013, Springer, Pérez-Arriaga, Ignacio J. (Ed.). ISBN 978-1-4471-5033-6.

Trinomics, 2016. Selecting Indicators to Measure Energy Poverty. Final report of the project *Energy Poverty - Assessment of the Impact of the Crisis and Review of Existing and Possible New Measures in the Member States*, released on 18 May 2016.

Ürge-Vorsatz, D., Tirado Herrero, S., 2012. Building Synergies between Climate Change Mitigation and Energy Poverty Alleviation. Energy Policy, vol. 49, pp. 83-90.

VCWG, Vulnerable Consumer Working Group, 2016. Working Paper on Energy Poverty.

VCWG, Vulnerable Consumer Working Group, 2013. Guidance document on vulnerable consumers. Working document released in November 2013.