The use of progressive tariff structures to align the interest of Utilities and of individual customers with the societal goal of enhanced end-use efficiency

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SYNOPSIS

A carefully designed progressive tariff can align the interest of Utilities and of individual customers with the societal goal of enhanced end-use efficiency and environment protection.

ABSTRACT

As to a tool to promote end use energy efficiency following the introduction of retail competition in newly liberalised markets much attention is often given to the creation of energy saving funds to finance DSM the activities. We argue here that the adoption of market and regulatory tools to **align** Utilities' shareholders interest and customers interest with end-use energy efficiency objectives continues to be of paramount importance.

The presence of elevated marginal profits connected to the sale of electrical energy (far superior to the marginal average unitary gains) not only discourages Utilities from undertaking DSM actions, but rather provides incentives to follow policies which aim to increase sales. To offset the such disincentives and incentives it is necessary to introduce suitable tariff mechanisms which decouple either partially or totally Utility profits from electricity sales (e.g. NLRA, Revenue Cap). In addition it can also prove extremely useful to develop a electricity price structure which provides Utilities and the end users with an additional economic signal to reduce energy use.

In the present article we propose a new enhanced progressive structure for the domestic customers tariff of electricity, where however that the part of the tariff which goes directly to the Utility is a flat or even regressive. The result would be that customers still receive a strong signal of high marginal economic savings when undertaking energy saving activities, while most of the disincentives for Utilities to decrease sales are removed. In this way the we decouple the price signal provide to the Utility and the end user.

The fundamental characteristic of the proposed structure is that reductions in Utility sales (due to DSM activities) provide variations in only marginal and not average economic returns; total Utility incomes and «the national energy bill» therefore remain unchanged.

Though the analysis in made in respect of the Italian domestic tariff structure the results are of global applicability. Even when energy prices (not just electricity) are completely liberalised as long as these (prices) contain government imposed taxes and industry regulatory authority defined fuel clauses the proposed structure is of relevance.

INTRODUCTION

Due to the introduction of retail competition in a number of countries, the focus of governments and regulators willing to ensure the delivery of certain public benefit programs, e.g. energy efficiency (DSM) programs, has progressively shifted from the adoption of various types of price regulation which reduce or eliminate the disincentives Utilities may face to undertaking energy efficiency programs, towards the creation of energy saving funds to finance the activities of a number of actors (generally including energy Utilities). But in an important part of the European electricity market (Italy, France , Belgium...) tariffs for the majority of customers will continue to be regulated, as they will be most everywhere in respect of those parts of the business (transmission and distribution) which are still considered natural monopolies.

We argue here that the adoption of market and regulatory tools to **align** Utilities' shareholders and customers interest with end-use energy efficiency objectives continues to be of paramount importance even in the case of direct interventions of government and other entities. Lack of the former instruments is likely to lead to conflicting signals: a signal to increase energy efficiency in certain end uses and customer classes for ESCOs, Regional Energy Agencies, retailers and installers of end use efficiency products[1], and powerful incentives for Utilities to expand consumption in all end-uses. The result would at best be a Nash equilibrium, as in other cases where a number of actors are playing against each other, instead of the optimal equilibrium which can result in a situation where cooperation is made possible.

Further, for example, a pure price cap regulation makes the profits of Utilities vulnerable to end use efficiency actions undertaken by any actor (be it, Government, Regional Agencies, ESCOs, Energy Saving Trust or the end users themselves) or to the adoption of minimum efficiency standards. It is therefore probable that Energy Efficiency Programmes of actions aimed at Market Transformation would find little support from the Utilities if not outright hostility. A satisfactory position of competition for the products and services of energy efficiency requires that any number of actors are able to survive in the market; producers, retailers and suppliers of end use efficient products, ESCO's, end users etc. The Utilities would have an essential role to play in any efficiency market, providing information on consumption characteristics necessary to determine the savings potentials and providing metering and billing support. However with a Price-Cap regulation, Utilities which were to provide such services in support of efficiency programmes would suffer reductions profits due to the reductions in sales.

The UK situation is an example where a mix of tools have been adopted: an obligation for distribution companies to deliver a minimum amount of energy savings, a surcharge to collect the money to pay for direct costs of programs, tariff regulation mechanisms designed to reduce the disincentives for Utilities to pursue energy efficiency in end uses. The UK Regulator recognised that price cap regulation *per se* creates an «*artificial disincentive to the companies promoting schemes to help customers use electricity more efficiently*» *(OFFER 1994), p.84* and has taken steps to reduce these disincentives. Following the regulation formula adopted in 1995 relative to Utility distribution activities, revenues are no longer 100% driven by sales volumes of sales being now instead weighted 50% by sales and 50% by customer numbers. Utilities are further rewarded for reducing losses on the grid by a mechanism which returning to them of quota of the economic benefit that would otherwise accrue entirely to customers. Some authors argue that the level of the surcharge and the tariff signal, though in the right direction, are not sufficient to achieve the energy saving results needed if the UK is to meet its CO2 commitment. Nevertheless the example indicates that even when wishing to promote end use efficiency actions through an entities other than Utilities (e.g. using the Saving Trust), the incentives provided by regulation can in no way be overlooked.

In the light of this scheme, we briefly examine current efforts and proposals to address economic motivations of different actors in the electricity market in Italy. The latest government documents propose vertical unbundling, a limit of 50% on the share of generation capacity owned by a single generation company and possibilities for municipal companies to slightly expand their distribution area. Realisation of this plan would change the role of the National Utility and open up more space for action to local distribution companies and other actors.

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1 eventually Distribution Utilities

For the municipal Utilities there is hence a desire to activate new services in line with their traditional public service role and the new possibilities to expand their activities. With an eye firmly on future commercial opportunities, under the auspices of Federelettrica (the municipal Utilities association), a research group (composed of the: Politecnico di Milano, Ambiente Italia, ENEA) is designing and evaluating pilot DSM projects with the Utilities of Turin and Cremona (within a SAVE II co-financed project).

Working with Utility engineers, the group has identified zones where the distribution network of AEM Torino is close to saturation; and more detailed load measurements are underway. To offset costly network improvements the Utility is willing to proceed with a localised IRP planning and DSM action targeted to domestic customer in the critical zones. Cremona has engaged in a pilot energy saving action of Third Party Financing in order to acquire experience with efficient end use technologies, develop TPF contracts and energy savings verification protocols. The profitability of these actions from the Utility perspective will be checked against whether the DSM cost recovery component [2] of the new price-cap tariff mechanism will be readily implemented or not.

But the recover of direct costs incurred in DSM programmes is not sufficient to induce Utilities towards the promotion of end use efficiency. The presence of elevated marginal profits connected to the sale of electrical energy (far superior to the marginal average unitary gains) discourages Utilities from undertaking DSM actions, in that almost always such actions result in significant profit losses. At the same time elevated marginal profits encourage Utilities to adopt policies aimed at increasing sales; this is ever more true under the newly introduce Price Cap mechanism for determining tariff rates than it was under the now extinguished Cost Plus Mechanism, in that the Price Cap will produce a reduction of marginal unitary average gains.

To contrast the both this disincentive to DSM actions and the incentive to increase sales, a number of tariff mechanisms have been studied which eliminate the loses to profits which result from the reduction of sales due to specific programmes aimed at improving end use energy efficiency, for example the NLRA (Net Lost Revenue Adjustment). There are also mechanisms, for example the Revenue Cap, which attempt to completely decouple Utility profits from energy sales. These mechanisms modify the average energy price, adjusting the total incomes for the Utility but do not modify the price structure (in respect of the variations between customer classes and in respect of single classes the variation as a function of consumption level)

To compliment these mechanisms which work at the global level, it can also prove extremely useful to develop a electricity price structure which provides end users and Utilities with an additional economic signal; which for the end users encourages reduced consumption and which for the Utilities shifts interest away from increased sales toward improving end use energy efficiency as a means to maintaining or improving company profitability.

In this context the present article considers energy pricing for domestic customers in Italy, analysing in so doing the economic incentive and disincentives for Utilities and end users of the present progressive price structure. The present structure, highly progressive with monthly consumption (up to 1/3 of EURO per kWh) has been strongly criticised by ENEL due to its lack of correlation between (industrial) costs and price, leading to net losses for lowest consumption customers. From many sides therefore there is a call for the introduction of a flat price structure for energy. From the energy efficiency point of view, if on one hand the present price progressive price structure provides an incentive for users to save energy, the present actual structure gives a strong disincentive to DSM actions to Utilities, which receive very high marginal revenue and profits from high consuming customers.

We are proposing a new enhanced progressive structure for the domestic customers tariff. We propose a mechanism where the part of the tariff which goes directly to the Utility is a flat rate, while the components of the tariff which go to the fund for fuel compensation and for taxation are designed to be highly progressive with consumption. The result would be that customers still receive a strong signal of high marginal economic savings when undertaking energy saving activities, while most of the disincentives for Utilities are removed. In so doing it is possible to decouple the price signal provided on hand to the Uility and on the other to the end user.

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2 proposed by L. Pagliano and J. Eto in 1995 and included in Law 481/95

The fundamental characteristic of the proposed structure is that reductions in Utility sales (due to DSM activities) effect only marginal economic values (the marginal price for users and marginal profits for Utilities) values and do not affect average values (average price and average profits): Since it is the marginal value which provides the signal with which the different actors deliberate on the whether to modify sales or consumption , it is possible to provide the correct economic signals without modifying the nature of the economic gains for providing the service; namely the total incomes for the Utility and the national energy bill.

It is possible in this way to provide the same price signal as would be provided by the internalisation of environmental and social externalities connected with electricity supply (for example, through the introduction of levies on energy use), and yet avoid the need to introduce notable increases in family expenditure at the national level that this option (externalities) would require. To provide some idea of the size of the cost to the Italian national energy bill for introducing externalities, we report results of calculations undertaken by the European Commission (Fontana, Furia et al. 1998). The study in question does not consider environmental damage connected to the «Greenhouse Effect»

Cost of externalities for the production of thermoelectric energy in Italy (figures do not consider the effects connected to the emission of CO2) [1 EURO = 1936.27 Lire - 100 L ≈ 0.05 EURO]

Fuel utilised	Without pollutant removal (L/kWh)	With pollutant removal (L/kWh)
Coal	200	45
Fuel Oil	150	35
Natural Gas (in combined cycle)	40	10

Fonte: Externe

Differences in location and climate can produce changes of the order of 300% with respect to the reported figures. Coriniar calculates that pollutant emission of electricity production results in damage to the environment of the order of 21 000 billion Lire/year, or roughly 50% of ENEL turnover, or 1.2% of the GDP of 1995 (remembering that damage due to CO2 emissions is not taken into account since there are large degree of uncertainty). It could be supposed therefor that internalising externalises would result in increases of roughly 50% in electricity prices and therefore the national electricity bill.

ELECTRICITY PRICE STRUCTURE IN ITALY

Electricity pricing for domestic customers in Italy is regulated by the *Autorità per l'energia elettrica ed il gas,* the independent industry watchdog authority.

Prices are composed of:

- a tariff to cover supply costs
- various taxes which flow to different levels of government (local, regional and state).

The *tariff* is itself composed of:

- a component to cover the fixed costs of electricity supply, the income from which is kept by the *supplier*
- a component to cover variable costs and onerous system costs, income from which is first directed to the *Cassa Conguaglio Settore Elettrico* (CCSE) (a fund maintained by the Ministry of Industry for the electricity industry), and subsequently accredited to the energy company on the basis of actually incurred costs.

These price components are articulated in a binomial structure, consisting of a:

p_e : variable price component (relative the level of consumption) [Lire/kWh]

p_p : fixed price component (relative to the contracted power level) [Lire/kW]

From which it is possible to express the variable component as:

$$p_e = p_e^S + p_e^C + p_e^G$$

p_e^S : sub component of the variable price component destined to the Electricity Supplier
p_e^C : sub component of the variable price component destined for the CCSE
p_e^G : sub component of the variable price component destined for the different Levels of Government

Considering any domestic customer we have:

p_m : marginal price of energy

intended as being:

the cost of purchasing 1 additional kWh or the *economic saving of achieving a reduction of each one 1 kWh*, with respect to the actual consumption level of the customer considered

Considering the behaviour of the single customer we can make the following hypothesis:

domestic customers do not change their contracted power rating following a reduction in their demand for energy and in particular following measures which increase end use efficiency.

Generally domestic customers display a certain rigidity with regards modifications to contracted power ratings and changes, if any, are made on the basis of other factors.
Thus we can see that for domestic customers, marginal energy price is equal to the variable price component[3]:

$$p_m = p_e$$

The three sub-components of the variable price component thus constitute the marginal income for the 3 actors considered above:

I_m^S ($= p_e^S$) : marginal income for the *Supplier*
I_m^C ($= p_e^C$) : marginal income for the *CCSE*
I_m^G ($= p_e^G$) : marginal income for the different Levels of *Government*

intended as:

the income obtained from 1 kWh of additional consumption by a customer or as the *income lost for each one 1 kWh saved by a customer*

From which we have:

$$p_m = I_m^S + I_m^C + I_m^G$$

and therefor for a domestic customer the variation in expense for each variation in consumption of 1 kWh (positive or negative) is the sum of the variation of income for the three actors considered: Supplier, CCSE and Government.

THE PRESENT PRICE REGIME FOR DOMESTIC CUSTOMERS IN ITALY

The progressive price structure for domestic customers with contracted power rating of 3 kW of less.

Presently for domestic customers in Italy with a contracted power of 3 kW or less (80% of customers and 90% of consumption) the price structure is within a certain limit progressive with consumption.

For customers within this category the variable price component p_e (and its associated sub components p_e^S, p_e^C, p_e^G) varies with the level of consumption of each individual customer and thus consequently so does the marginal income I_m^S, I_m^C, I_m^G for the three actors.

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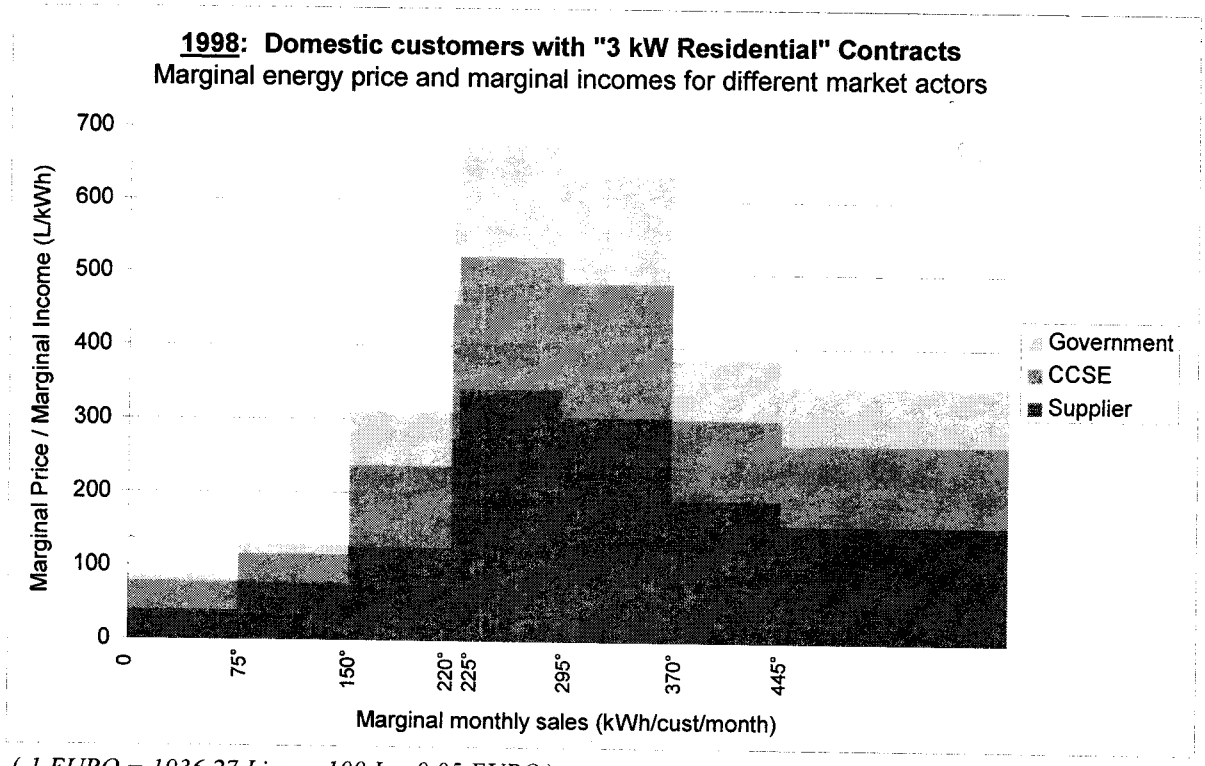
3 following the variation in consumption by a user, the only variation to his bill is in relation to the energy price component, p_e

The following graph illustrates the marginal price of energy [4], and the three subcomponents for a customer with a contracted power rating of 3 kW:



(1 EURO = 1936.27 Lire - 100 L ≈ 0.05 EURO)

Note that price is progressive for customers consuming less that 295 kWh/month (roughly 3500 kWh/year). Above this level marginal price starts to decline.

It is important to underline that within the present price structure Supplier marginal income (I_m^S) is also progressive in line with the customer consumption.

Incentives and disincentives of the actual progressive price regime

Considering the signal that the price regime imparts to customers we can say:

> the progressive structure of energy price provides a stimulus to customers to introduce measures to increase end use energy efficiency

Indeed for a large number of customers the marginal price of energy is very high (aroung 600 L/kWh or 0.3 EURO/kWh) and therefor provides an incentive for the introduction of energy efficiency measures. It is reasonable to assume that the better response to DSM efficiency programmes would be obtained from these same medium to high consuming domestic customers.

Further, if we consider environmental and social costs, we can assume that the progressive regime correctly transmits the price signal that marginal cost of electricity supply increases with the increased total supply of energy.

Though in general we can consider that the progressive price regime provides a positive incentive for customers to introduce end use efficiency measures, we must however also recognise that the actual structure presently in force in Italy has a number of negative aspects.

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4 as of 31st December 1997

In particular considering customers, we note that the present price structure:

- was not developed as a means to manage demand but rather as a instrument to protect and assist disadvantage sectors of society and is therefore not calibrated on pre-defined objectives of energy efficiency.
- is relatively incomprehensible to the standard customer and therefore the price signal towards improved efficiency is difficult to read [5]
- is not fair: the various categories of customer are treated differently [6]

And considering for a moment suppliers, and remembering that marginal income is also progressive, as explained above, we note that:

- the price rates of that component destined for the Supplier p_e^S do not relate directly with cost of supply and result in cross subsidises between the different customer classes
- the price structure provides a disincentive for Suppliers to realise DSM programmes; indeed Suppliers obtain the greatest profits from those customers which would potentially offer the greatest benefits (largest savings) from DSM programmes; namely those customers with medium to high consumption.
- the price structure provides Suppliers with an incentive to increase sales of energy, by marketing to increase sales to those customers offering Suppliers high marginal profits,

We can conclude therefore that in relation to increased energy efficiency the negative aspects of the actual progressive price structure outweigh the positive aspects. Surmising therefore the actual progressive price structure:

+ essentially provides the correct price signal to customers, and therefore provides an incentive to customers to invest in measures to increase end use efficiency.
− it is complex and difficult to comprehend and therefore the price signal proves difficult to interpretate by customers
− it is unfair, offering excessively low average prices for some categories and high average prices for others
− the different price rates do not relate directly with the effective costs of supply and therefore provide an incorrect signal towards Suppliers
− provides a disincentive for Suppliers to undertake DSM programmes and indeed provides a incentive for these to increase sales of electricity.

One way to remove the negative aspects is to introduce a flat tariff rate; however this solution would also obviously destroy the important positive attribute. Fortunately it is possible to allay the negative aspects whilst maintaining the progressive price structure. To do so, the group proposes a two tier structure, a first flat tier for Supplier incomes and a second progressive tier which collects incomes for the CCSE and the different Levels of Government.

AN HYPOTHETICAL FLAT PRICE REGIME

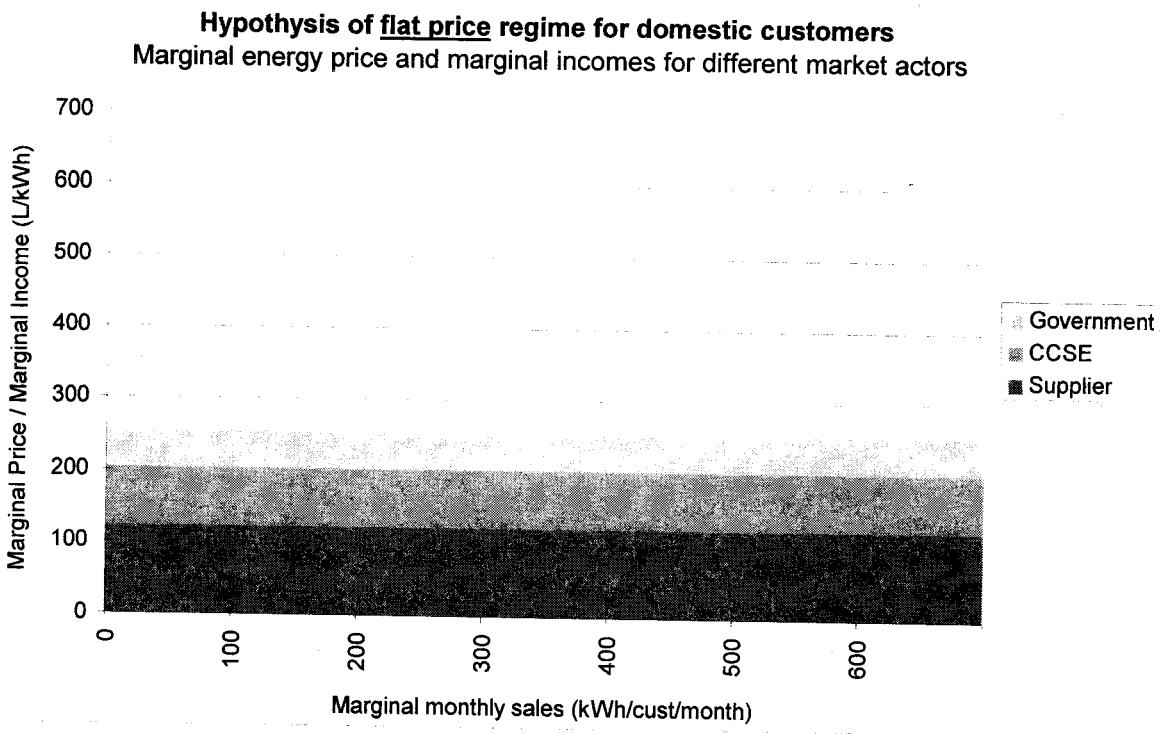
With a «flat price regime» the variable price component p_e, and the various sub components p_e^S, p_e^C, p_e^G, is/are invariable with customer consumption. At the present moment of time in the development of electricity sector in Italy, the «Flat Tariff» is proposed most often as the preferred alternative to the actual Progressive Tariff.

A flat tariff regime is shown graphically in the following figure [7].

5 also because the progressive increase in price above to 220 kWh/month is not explicitly shown on the electricity bill

6 in particular the average price of electricity for «resident» customers with contracted power rating of 1.5 kW is very low, whilst the price for electricity «resident» customers with contracted power rating above 3 kW and «non resident» is very high.

7 Price levels have been chosen in order that cash flows to the different receiving bodies (Supplier, CCSE, Government) remain unaltered with respect to the present day situation.



(1 EURO = 1936.27 Lire - 100 L ≈ 0.05 EURO)

With such a price regime, a number of negative aspects would be if not eliminated at least attenuated:

- the price structure is simple and easy to comprehend.
- there is no discrimination between the different customer categories, in that each customer pays the same price for energy
- price rates effectively reflect average production costs [8]
- the disincentives for Suppliers to undertake DSM programmes are reduced, since there are no longer customer classes which offer higher then average marginal incomes and then very high profits.

However the incentive for domestic customers to introduce measures to increase end use energy efficiency would be also be notably reduced, eliminating the price signal of increased supply cost (including environmental and societal costs) for increased consumption.

A PROPOSAL FOR A RATIONAL PROGRESSIVE PRICE REGIME

In order to reconcile the positive aspects of a flat price regime with the incentive for improved end use energy efficiency provided by the progressive regime, we propose a price regime in which:

- the price component which covers Supplier incomes is flat; that is price rates p_e^S are invariant with consumption.
- the price component which covers incomes to the CCSE and Government Agencies is progressive, that is the rates of the components p_e^C e p_e^G increase with customer consumption
- the progressivity is simple: 5 price bands of the same extension and with a constant factor increase
- the progressivity is the same for all categories of customer: price bands are calibrated on the basis of utilisation of the contracted power ratings [9] and not on the level of consumption

8 In reality in order to equate prices with costs it would be necessary to include a pricing structure based on «time of day» use, in as much as supply costs vary according to the time of supply.

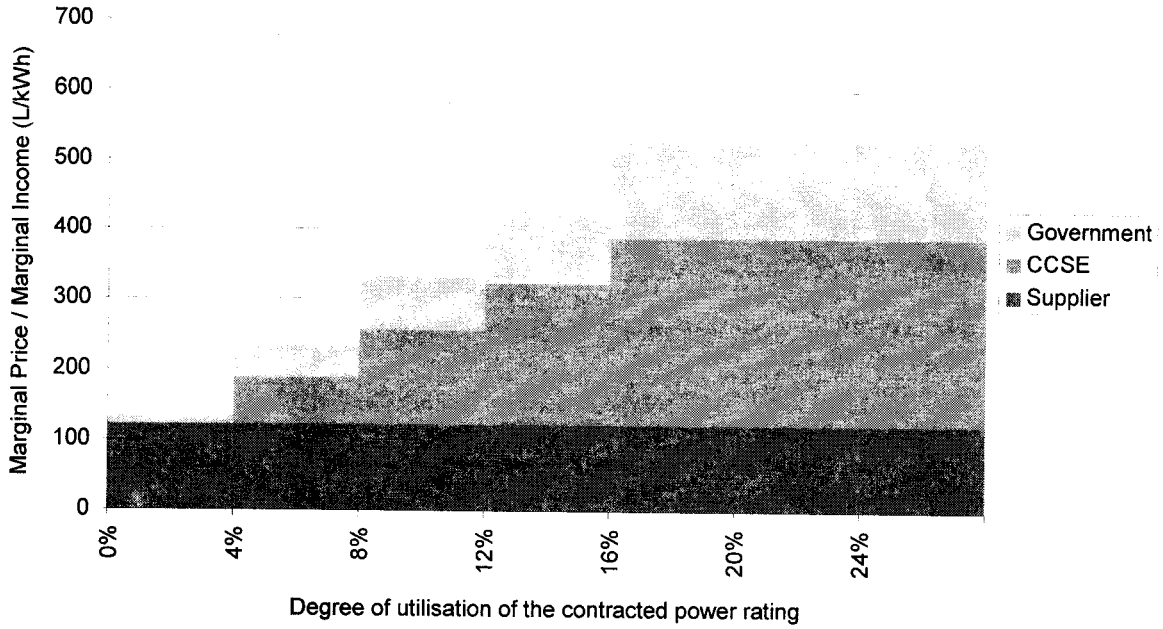
9 Each contracted kW allows a maximum consumption of 8760 kWh/year. The level of utilisation made by a customers measures the actual level of consumption with respect to the theoretical maximum for each kW contracted; this can be expressed ad KWh/kW/year, in hours/year or as a percentage of the maximum consumption.

For the purpose of exposition we consider the following degrees of utilisation of the contracted power rating[10]:

0 - 4 % - 8 % - 12 % - 16 % - ...

We consider an hypothetical progressive structure in which those price components providing incomes for the CCSE (p_e^C) and Government are set at zero (with the exception of VAT, at 10%). The structure is exemplified in the following graph.

Proposal 1: progressive price regime for domestic customers
Marginal energy price and marginal incomes for different market actors



(1 EURO = 1936.27 Lire - 100 L ≈ 0.05 EURO)

In order to avoid a customer increasing his contracted power rating in order to obtain lower tariff rates for the same level of consumption it is necessary to calibrate the rates for the different contract power levels p_p, in such a way that it becomes economically convenient to do so (i.e. increase contracted power rating) only above predetermined threshold consumption levels.

With such a price regime the marginal income for the Utility I_m^S is flat, that is independent of consumption level.

The proposed progressive price regime thus allows the positive aspects of both the progressive and flat regimes to be combined:

- the incentive for customers to invest in end use efficiency measures is maintained, by providing the correct price signal of increased cost (including social and environmental) for increased total supply
- the structure is simple and comprehensible
- there is no discrimination between the different customer categories; the average energy price is the roughly the same for each customer category
- price rates for Suppliers are aligned roughly with average supply costs
- the disincentives for Suppliers to undertake DSM programmes and the incentives to increase sales are reduced, since there are no longer customer classes which offer higher then average marginal profits.

10 Statistics available on domestic consumption in Italy indicate that the average customer, for each contracted power category, occupies the third band.

Surmising, with respect to the actual progressive tariff regime the proposed regime:

Reduces the incentive for Suppliers to increase sales

Eliminates price discrimination between the different customer categories

Conserves and improves the incentive for customers to invest measures to improve end use efficiency

A REGRESSIVE VARIABLE PRICE COMPONENT DESTINED FOR SUPPLIERS

We must stress that with our proposal of a progressive price regime:

- the disincentives to undertake DSM programmes for efficiency
- the incentives to increase sales

now presents for Suppliers, are reduced but not eliminated.

In fact with its introduction there are no longer customer classes which offer very high marginal profits, but positives marginal profits still exist on the mean of additional energy sales.

In order to reduce even further these disincentive to DSM and incentive to increase sales, it is possible to construct the tariff in such a way that :

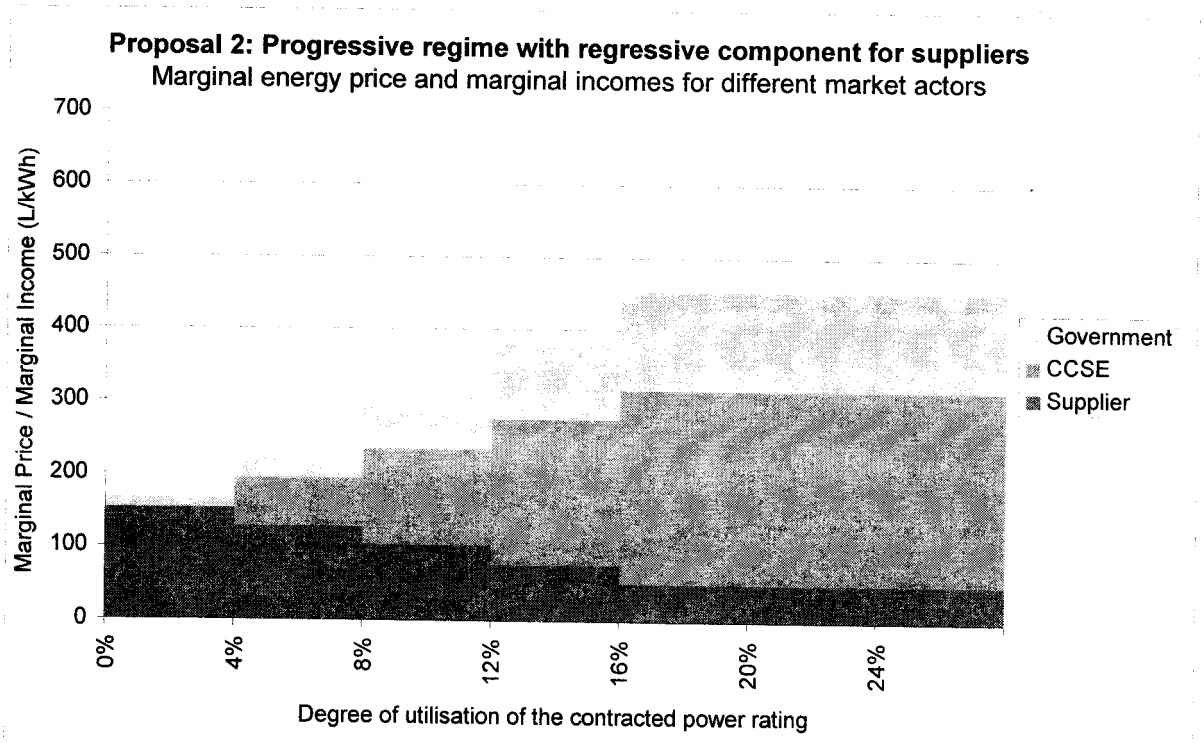
the variable component of price destined for the Supplier p_e^S is regressive with consumption.

Reducing the marginal income for to the Supplier I_m^S as customer consumption levels increase would result in reduced marginal profits for the Suppliers and would lead therefore to a partial ***decoupling of profits from sales***, in as much as total profits would grow less than proportionately with increases in sales.

Constructing the tariff such that p_e^S is regressive with consumption would not modify the total value of global incomes and therefore global profits for the Supplier. What would change is that increased incomes, and therefore increased profits due to increased sales would be less than in the case if the tariff regime, that is p_e^S were flat

As way of example we introduce a regressive component into the progressive regime previously proposed above [11], the result of which is shown in the following graph.

11 The rate of decrease in the price component providing income to the Suppliers, p_e^S, has been chosen such that the total incomes to the supplier remain invariant with respect to present day incomes.



(1 EURO = 1936.27 Lire - 100 L ≈ 0.05 EURO)

CONCLUSION

The progressive price regimes proposed in this article contain numerous positive aspects for the diffusion of end use energy efficiency, and more in general for the greater objectives of the tariff reform underway in Italy. In general we are seeing a move towards the realisation of the harmonisation of *energy efficiency objective* with the *financial economic objectives of the Utilities*. In such an environment it is debatable whether this could be achieved with a flat price regime.

With the introduction of a flat structure (or even degressive) for the price component destined for the Supplier p_e^S, we reduce both the disincentives to Suppliers to undertake DSM programmes and the incentive to increase sales, but we don't get to their removal. In order to eliminate the disincentive to DSM actions and the incentive to increase sales it is necessary to increase mechanisms which de-couple profits from sales (including the Revenue Target mechanism to update tariffs and the general reduction of the variable part of the price for the quota destined for the Supplier).

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