Criteria for the Assessment of Demand Side Management Measures in the Context of Electricity Sector Regulation

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***Abstract*--In the present regulation of electricity sector, the distribution companies, acting as the electricity public system (SEP) supplier, can promote demand side management (DSM) measures. In order to promote the implementation of these measures, the Tariff Code establishes that the implementation costs of a measure and half of the net benefits will be reflected in the SEP supply tariffs.**

In this paper we analyze different criteria for valuing DSM measures, evaluating its effect in benefit cost ratio of the measures, in its merit order, in the total benefits value and, lastly, in the value that will be accepted in the SEP supply tariffs. It is shown that despite the attribution of high environmental premiums for the implementation of DSM measures, the costs for ton of CO_2 avoided are more reduced than those which would result from the implementation of equivalent measures from the supply side.

***Index Terms*-demand side management, energy efficiency, environmental premiums, economic regulation.**

I. Introduction

THE measures for efficient use of electricity promoted by the companies supplying electricity are usually named as demand side management (DSM) measures. From the point of view of a regulated company it is important to put the incentives and costs of DSM programs side by side with the other instruments of economic regulation.

These measures must be valued bearing in mind that its costs will be supported by the electricity consumers knowing, nevertheless, that the benefits resulting from a more rational consume of electricity will affect not only the consumers and companies of the sector, but society as a whole.

Bearing in mind the necessity of promoting this kind of DSM measures, the Portuguese energy regulator (ERSE) established in 2001 in the Tariff Code a disposition which obliges the distribution company, acting as the electricity public system (SEP) supplier, to define a DSM program, for each regulatory period, where should be presented measures and programs to be undertaken in each year of the regulatory period, showing clearly the objectives and discriminating the respective costs and benefits which are to be achieved [1, 2].

The Tariff Code defines how to calculate the revenues for the SEP supply activity, which includes the *a posterior* recognition of the costs and benefits with the DSM measures foreseen in the DSM program. The model for determining the costs and benefits is settled in the beginning of the regulatory period.

In the revenues established by the Tariff Code 50% of the net benefits related to the DSM measures are accepted. Additionally, the costs with the implementation of these DSM measures are accepted, if they have been programmed and foreseen.

Considering that 50% of the costs and benefits are reflected in the tariffs, there should be a particular care in the economic valuation of DSM measures. In this paper we discuss different valuing criteria for DSM measures.

The present paper is organized in the following way. In section II.A we discuss different economic criteria for evaluating the DSM measures. In section II.B we present the economic criteria for valuing the DSM measures, established for the 2002-2004 regulatory period, which will be considered in the calculation of the eligible costs and benefits that will be recovered by the SEP supply tariff, paid by the SEP consumers. In section III.A five DSM measures are established, presenting the characteristics of each one. These measures have been conceived by the authors, having in mind the analysis of the influence of the several economic criteria for the evaluation of the DSM measures. In section III.B we simulate the impact of the several economic criteria (i) on the value of costs and benefits of the DSM measures, separated on the environmental and bill reduction parcels, (ii) on the measures benefit/cost ratio and (iii) on the amount of revenues to be recognized on tariffs, evaluating the correspondent impact. It is also presented some environmental indicators associated with the proposed measures, accordingly to the economic criteria of valuation established for the 2002-2004 regulatory period. In chapter IV we present the paper conclusions.

II. Economic Criteria for Evaluating DSM Measures

In the scope of electricity sector regulation it is allowed to the distribution company the possibility to share the benefits

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from the DSM measures it promotes. The benefits can be considered on a social perspective, either in terms of reduction of the values of energy bills, or by the reduction of the environmental impacts.

The bill reduction resulting from a DSM measure is an adequate image of the set of costs subjacent to the supply of electricity. This unity of measure of the benefits is useful, as long as it brings the perspective of the society in the consideration of DSM benefits, concentrating the two parcels that are usually taken into account - the benefits to consumers and the benefits to the supplier.

The environmental benefits are associated to the reduction of negative externalities related to the environmental impacts of the electric sector. Nevertheless, the valuation methodology of the environmental costs is a controversial subject, where considerable uncertainty subsists.

The benefits associated to the bill reduction and to the reduction of the environmental impacts are calculated on the basis of the comparison between the more efficient technology and the standard technology of the market, which offers a similar service.

In the measures which foreseen the financing of part of the cost difference between the equipment more efficient and the standard, the benefits result from the financing of the cost difference and should be reflected in the tariffs, in the percentage of the financing given.

A. Discussion of the economic criteria for valuing DSM measures

The valuing of DSM measures may be a source of big controversy; hence several hypotheses may be adopted. The adopted hypotheses have influence on the benefits and costs of the measures, as it will be shown in section III.B.

Starting from a base hypothesis for valuing DSM measures several alternative methodologies are discussed, accordingly to table I.

TABLE I
VALUING HYPOTHESES OF DSM MEASURES

	Base Hypothesis	Alternative Hpothesis	
Period considered for the accounting of benefits	Period equal to the lifetime of equipments	**Pmax10**	Maximum period for valuing benefits limited to 10 years
		Pmax6	Maximum period for valuing benefits limited to 6 years
		P50%	Period equal to half of the lifetime of equipments
		P67%	Period equal to two thirds of the lifetime of equipments
Valuation of the benefits related to the bill reduction	100% of bill reduction is a benefit	**F75%**	75% of bill reduction is a benefit
		F37%	37% of bill reduction is a benefit
		F0%	Bill reduction is not an eligible benefit
		Rprov	Consumption reduction is a cost for the distribution company
Valorization of the environmental benefit	100% of the environmental benefit is eligible	**BA75%**	75% of the environmental benefit is eligible
Spreading the inclusion of costs and benefits	Inclusion of total costs and benefits in one year	**SC2**	Spreading costs and benefits in two years
		SC6	Spreading costs and benefits in six years
Discount rate for accounting the benefits	Discount rate equal to 3,75%	**TD+1%**	Discount rate equal to the base hypothesis plus 1,0%

1) Period considered for the accounting of benefits

One of the traditional hypotheses considers that the total benefits are calculated during the lifetime of the equipments promoted in each measure, being accounted in the year in which the measure is realized and, therefore, in the year of the costs accounting. From the point of view of regulated companies there is a propensity to require the accounting of the benefits in the year of realization of the measure, though they are calculated considering the lifetime of the equipments.

Although being acceptable the payment of the measures in the year of realization, it seems less acceptable the accounting of the benefits considering the total lifetime of the equipments, especially for equipments with long life times.

It is frequent that programs of incentives for investments in energy efficiency limit the counting period for benefits to a maximum value, because it is thought, that after this period the conditions of the market will have changed sufficiently, so that it will not be justifiable the accounting of this incentive. In fact it is expected that in a broad period (10 or 12 years) the market of equipments, which is being subsidized on the argument of dynamizing and transforming, has already achieved a sufficient mature stage and also that the environmental impacts have already been internalized in the electricity market.

The consideration of the technologic evolution in the medium term is another argument in support of the prudence for not considering long terms for accounting the benefits. Even in relation to the most efficient technology it is possible to argue that, in the future, it may become an obsolete technology without interest from the environmental or energy point of view. The promoted technology must be compared to the technology that would exist without the promotion, but it may be considered that the technological progress makes obsolete the less efficient technology, increasing the attractiveness of its substitution by the consumer, even if there is no subsidy.

Another argument that conditions the acceptance of long terms for counting the benefits concerns the evolution of the electricity markets in the European Union and, in particular, in Portugal. Supposing that the expenses (costs plus benefits) will be supported by consumers two years after the year of investment and given a current of future cash flows concentrated in that year, it is important to question if it is fair that those consumers support an economic effort that brings benefits for all, during a long period of years. From this perspective, of institutional and regulatory evolution of the electricity markets, the prudence would advice the consideration of periods for accounting the benefits included within a regulatory period.

Given the above arguments on the prudence for considering long terms on the accounting of benefits, two alternative hypotheses are examined in the present paper: limitation of the maximum period for accounting the benefits to 10 years (Pmax 10); and limitation of the maximum period for accounting the benefits to 6 years (Pmax 6).

Nevertheless, the truncation of the period for accounting the benefits has also disadvantages, namely, affects the benefit/cost ratios between the several measures. A measure whose equipment lasts longer is negatively affected by the limitation in relation to other where the equipment lasts less years. This aspect may distort the relative interest of the several technological options for promoting energy efficiency. Following this line, it would be useful to explore not a truncation of the period for accounting the benefits, but a truncation of that period to a percentage of the lifetime of the equipments. The aim is to distinguish between the lifetime of equipments in technologic terms and the lifetime of the equipments relevant in economic terms.

Given the exposed on the truncation of the accounting period, two additional hypotheses are considered, where the accounting period of benefits is defined as a percentage of the equipments lifetime. The two additional proposals consider a period equal to half or to two thirds of the equipments lifetime (P50% and P67%, respectively).

2) Valuing costs and benefits related to the electricity bill reduction

The consideration of 100% of bill reduction as a benefit of DSM measures is a strong hypothesis and an extreme of the several possibilities of analysis. To take into consideration as a benefit of DSM measures, those that the consumers would not pay in their electricity bill, implies the assumption that there is no variation in the producer surplus, that is, the social benefit is equal to the variation in the consumer surplus. Nevertheless, the only case where the producer surplus does not change with the reduction of quantity is when the price is equal to the supply marginal cost, once this is a requisite for the reduction of revenues to equal the reduction of costs. As already stated, this is a strong hypothesis, which corresponds to an extreme theoretical situation.

An alternative, is assuming that the costs associated to electricity supply enclose components that do not depend on the quantity supplied, that is, considering the existence of costs that do not change with the quantity. In practice, it is admitted that electricity supply prices are higher than marginal costs, implying a negative variation in producer surplus when there is a reduction in the quantity supplied, once the reduction in revenues is higher than the reduction of costs. This means that the social benefit is not any more equal to the variation in the consumer surplus, being equal to the sum of the variation on the consumer surplus (positive and equal to the reduction in the bill) and on the producer surplus (negative and equal to the difference between marginal costs and total unit costs).

It is important to state that in the current situation of SEP, where financial-economic producer's equilibrium is secured by the existence of electricity long term acquisition contracts, the reduction of the producer surplus is recognized in the electricity tariffs, being supported by SEP consumers in the following two years. In this situation, there is still a reduction of the social welfare, because there is only transference of the loss from the producers to the electricity consumers.

In Portugal, in the second period of the electricity sector regulation (2002 to 2004) the difference between the allowed revenues for the SEP supplier and the revenues that would be obtained by tariffs equal to marginal costs was 25,6%, this is, 74,4% of costs change with the quantity supplied. With these values, the welfare change would be 74,4% of the bill reduction (100% consumer benefit and -25,6% producer benefit). So, an alternative hypothesis is considered, named "75%", in which the benefit is 75% of the bill reduction.

If a short term perspective is adopted and the only costs considered as sensitive to quantities are those concerning the energy parcel of the Energy and Power tariff (tariff which allows the recovering of the electricity acquisition costs of the SEP supplier), the value of the benefit concerning the electricity bill reduction is 37%. This is another hypothesis, being named "F37%" and reflects the benefit of bill reduction associated with the generation marginal costs. The application of this criterion to the current situation in SEP, corresponds to considering that 63% of the bill reduction corresponds to losses of electricity sector companies namely due to the infrastructures, being this losses transferred to the SEP consumers in the following two years.

Another extreme hypothesis, which is important to consider is not to take into consideration any benefit due to the bill reduction. So, it is also considered another hypothesis "F0%", that may have two interpretations: the costs are all fixed (very short term perspective); or the benefits are appropriated by the consumers participating in the program and are not shared.

Alternatively to the previous hypotheses, the electricity bill reduction may, from the electricity supply companies' perspective, be considered as a cost from DSM measures. From this perspective, the benefit parcel from bill reduction would be considered as in hypothesis "F37%", reflecting the variable costs associated to generation, being determined a value to be considered as a cost on the perspective of the SEP supplier. The reduction of active energy supplied has a negative impact in the activities regulated by price cap, because the allowed revenues change with the quantities supplied. Nevertheless, this change will happen only until the next price control revision, this is, until the new regulatory period. In this context, and from the distribution company perspective, only the electricity distribution activity, which is regulated by price cap, is negatively affected with the reduction of electricity supplied. Given the exposed, it was considered another hypotheses, in which the consumption reduction leads to a reduction of electricity distribution revenues, with a unit value equal to the price cap (RProv), maintaining as a benefit the same that was considered in hypothesis "F37%". For determining this additional cost parcel it was assumed that the electricity consumption reduction leads to a reduction of the allowed revenues of two years. The analysis is done by voltage level. For simplicity reasons it was not considered the effect on the costs of the activity due to the reduction of quantities, which could be valued by incremental cost.

3) Valuing environmental benefit

The consideration of environmental benefits due to DSM measures allows the partial inclusion of environmental impacts in the electricity price. The environmental benefits, concerning the environmental impact reduction due to the electricity saving and its reflex on generation, were accounted through the formula established in the Decree-Law n.168/99, in which the rules applicable to special regime generators are established. The eligible environmental benefit considered is 74,8 euros per ton of avoided CO_2, resulting in a value of 2,77 cent €/kWh saved due to the implementation of DSM measures. For calculating this value it was taken as reference the emissions of a natural gas combined cycle plant (0,37 kgCO_2/kWh).

Nevertheless, the doubts and uncertainties about the valuation of this effect raise some questions, namely the adequate valuation for each ton of avoided CO_2. Given these doubts and uncertainties, it must be questioned if the electric sector should already incorporate in the price all this impact.

This question assumes even more relevance if other energetic products are considered, which are in competition with electricity, and do not incorporate environmental impacts on their prices.

In the present analysis, it was considered an alternative hypothesis "BA75%", where the accepted benefit for the electricity sector is 75% of the environmental benefit.

4) Discount rate for accounting the benefits

In the base hypothesis, the present value of the future benefits is accounted using a discount rate equal to 3,75%.

The fact that some measures have long payback periods suggests that it may be taken into consideration discount rates of compatible maturity. Thus, it was considered an alternative hypothesis, in which the discount rate used is increased by one hundred basis point.

Naturally, as higher is the rate the less is the present value of the benefits and, consequently, the less is the impact on tariffs. A higher discount rate is associated with a higher risk on the hypothetic recovery of benefits in the future.

In relation to the benefits environmental parcel the parallelism with the valuation of the energy generated by renewable sources suggests that the calculus of the present value takes into consideration a discount rate that reflects the opportunity cost of capital, in a compatible way with the opportunity cost relevant for an investor on generation electricity plant by renewable sources.

In what concerns the bill reduction parcel, this hypothesis has an equivalent effect to the consideration that the nominal tariff variations are, in average, lower than the average rate of inflation. This hypothesis may be in part justified by the achieving of efficiency gains by the regulated companies.

5) Period for spreading the inclusion of costs and benefits

In the base hypothesis it is used the present value of the benefits, calculated with a period equal to the lifetime of the equipments, and the total value is registered as being from the year when the measures are implemented.

The investments in equipment in the ambit of DSM cannot be considered as assets and subject to amortization in the perspective of the regulated company. In the same way, the accounting of the benefits in an annual basis would be difficult to do and the counting period could exceed the regulatory period.

Comparing the incentives attributed to DSM programs, with the incentives attributed to the generation of electricity through renewable sources, it is possible to see that the last ones are given periodically and based on avoided CO_2, month by month, not being the fixed capital subsidized by tariffs, but only the service associated with variable costs.

In the present paper this approach it is not followed and the costs and benefits referred to a shorter period of time are considered. Nevertheless, assuming that this period can only be of one year is very restrictive.

An alternative to the inclusion of all costs and benefits in one year might be to consider a regulatory period or the years that are missing for the end of that regulatory period, or even two regulatory periods, given the permanence in time of the effects of DSM measures. It must be considered the possibility of a greater equity between measures from the supply side and from the demand side, in terms of annual financial effort.

The change of the repartition period of costs and benefits does not change the measures rentability (neither for the companies nor for the consumers) it just spreads in time its impact on the allowed revenues of regulated companies. Thus, its impact is not simulated in this paper.

B. Economic criteria for valuing DSM measures established for the 2002-2004 regulatory period

Given the several hypothesis for valuing the costs and benefits of DSM measures presented above, it were selected the criteria more adequate to the regulation in force in the 2002-2004 regulatory period. There was a concern in identifying ways for valuing the benefits that (i) reflect the point of view of the electric sector, without forgetting the context of the several energy and environmental politics that intersect the regulation of the sector, (ii) ensure equity between actual and future electricity consumers, (iii) ensure equity between supply side and demand side measures in terms of avoided CO_2 emissions and also (iv) ensure equity between several type of concurrent energies.

The valuation criteria of the costs and benefits of DSM measures established for the 2002-2004 regulatory period where the following: (i) Present value calculated with the economic lifetime of equipment; (ii) Discount rate of 3,75%; (iii) Environmental benefit corresponding to 100% of the calculated value; (iv) Electricity bill reduction benefit corresponding to 37% of the calculated value; (v) Economic lifetime of the measures determined as 2/3 (two thirds) of the lifetime of equipments, round to year, being this value limited to six years.

III. Evaluation of results and impact assessment

The economic criteria discussed in Chapter II are applied to five DSM measures defined in Section III.A. Section III.B presents, for each criteria and for each DSM measure, (i) the respective costs and benefits, distinguishing between bill reduction benefits and environmental benefits, (ii) the cost benefit ratio, (iii) the amount of allowed revenues to be included in the supply tariffs and the impact it causes to consumers, and (iv) the cost per ton of avoided CO_2 emission as well as the cost per kWh of saved energy.

A. DSM measures to be evaluated

With the view to simulate the effect of the different economic criteria it is necessary to define a set of representative DSM measures. The proposed measures must be selected considering their merits in terms of energy consumption reduction and load management optimization. The purpose of the economic criteria used is not only to determine the correct amount to be paid in the tariffs but also to select the measures to be implemented among a vast array of possibilities. For the present study five DSM measures where chosen, all with high benefit/cost ratios, and stated bellow:

- Residential lightening: use of more efficient lights, fluorescent compact lights, in households.
- Electronic ballasts: use of Electronic ballasts in the service sector.
- Electronic speed variator: use of electronic speed variators in industry with the objective of increasing industrial process's efficiency. In particular, regarding control and start up of applications like pumps, ventilators and compressors.
- Efficient motors: use of efficient motors in industrial applications with high number of operating hours.
- Public lightening: use of sodium high pressure lamps in public lightening equipment.

The DSM measures presented and designed in table 1 are to be taken as examples. The design of the measures and associated discussion are not subject of this paper. For this purpose another set of measures could have been chosen. The characterization of this DSM measures is necessary in order to proceed to the evaluation of results and impact assessment associated with the different economic criteria for valuing the measures.

When designing a measure like the ones above, from the electricity sector perspective, there are two distinct ways for promoting the acquisition of more efficient equipment: (i) financing the purchase of the equipment giving a percentage of the cost that can vary or (ii) financing only part of the difference between the more efficient solution and the standard one typically chosen by the market, thus breaking the so called "technological barrier". Each approach has its merits and has implications in the quantification of benefits and costs.

TABLE I – TECHNICAL CHARACTERISTICS OF THE MEASURES

Measure	Assumptions
Residential lightening	Aimed for the household sector. Fluorescent compact light of 21W substituting an incandescent light of 100W. Financial support: 20% of cost. Unit cost: 5 EUR. Applicable tariff: Standard Low Voltage tariff (StLV) with 2 time-of-day energy periods. Average use: 3 hours/day (38% in off-peak period and 62% in peak period, [3]). Annual energy saving, per unit: 87 kWh. During is useful lifetime one fluorescent compact light substitutes 6 incandescent lights. Useful lifetime: 6 years.
Electronic ballasts	Aimed for the service sector. Electronic ballast applicable in luminaries with 2 lights of 58W [4]. Financial support: 25% of the cost difference to the standard technology. Cost difference to the standard technology: 25 EUR. Applicable tariff: Special Low Voltage tariff (SpLV) with 3 time-of-day energy periods. Ballast use: 8 hours/day (75% in partial-peak time and 25% in peak time). Annual energy saving, per unit: 99 kWh. The avoided consumption of electricity is valued using active energy prices and average peak power price (considering 1460 peak time hours per year corresponding to the daily schedule). Useful lifetime: 13 years.
Electronic speed variator	Aimed for the industrial sector. Introduction of Electronic speed variators in processes that can benefit from speed regulation for energy efficiency improvement, like pumps with variable flows [5] - [7]. Financial support: 10% of cost. Unit cost: 4000 EUR. Applicable tariff: Special Low Voltage tariff (SpLV), Medium Voltage tariff (MV) and High Voltage tariff (HV). Savings up to 25% of consumption in comparison to the use of adjustable valves. Speed regulation in 22kW motors, considering an average use of 6000 hours/year. Usage is considered in accordance with the daily schedule, for SpLV and MV, and weekly schedule for HV. Annual energy saving, per unit: 25 000 kWh. The avoided consumption of electricity is valued using active energy prices and average peak power price (considering number of peak time hours per year corresponding to the applicable schedule, daily schedule or weekly schedule). Useful lifetime: 15 years.
Efficient motors	Aimed for the industrial sector. Introduction of more efficient motors substituting conventional ones of 18,5kW, considering an average load regime of 27% and 4700 hours of use per year [8]. Financial support: 25% of the cost difference to the standard technology. Cost difference: 260 EUR. Applicable tariff: Special Low Voltage tariff (SpLV), Medium Voltage tariff (MV) and High Voltage tariff (HV). Savings up to 25% of consumption in comparison with conventional motors. Usage is considered in accordance with the daily schedule, for SpLV and MV, and weekly schedule for HV. Annual energy saving, per unit: 3150 kWh. The avoided consumption of electricity is valued using active energy prices and average peak power price (considering number of peak time hours per year corresponding to the applicable schedule, daily schedule or weekly schedule). Useful lifetime: 15 years.
Public lightening	Applicable in public lightening systems. Introduction of 70W sodium high pressure lamps substituting 125W mercury vapour lamps [4], [9]. Financial support: 25% of the cost difference to the standard technology. Cost difference: 10 EUR. Applicable tariff: Public lightening tariff in Standard Low Voltage (StLV). Average use: 10 hours/day. Annual energy saving, per unit: 201 kWh. Useful lifetime: 3,5 years.

The number of interventions in each measure was determined in order to obtain an effective total implementation cost exactly the same to each of them.

The cost of each measure was, in those terms, fixed in 100 thousand Euros, being the overall cost of the programme with the five measures adding 500 thousand Euros.

B. Influence of the economic criteria on the appraisal of the different measures

Fig. 1 presents the value of the benefits on each of the valuing scenarios previously discussed for the five measures of DSM considered. The value of the benefits is disaggregated in the bill reduction benefit part and in the environmental benefit part (except for the "RProv" criteria that, for purposes of graphic viewing the eligible cost for the distributor is considered as a negative benefit, thus the bill reduction benefit part appears deducted of that cost). The same figure also presents the result of valuing those measures with the criteria established by the regulator for the 2002-2004 regulatory period, presented in Section II.B, named as hypothesis "Final".

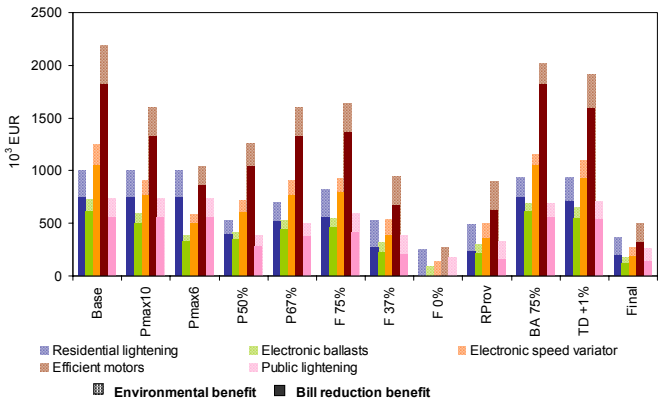

Fig. 1 Benefits of each measure according with different criteria.

Several of the alternative criteria included in the final hypothesis underline the relative weight of the environmental benefits in relation to the bill reduction benefits. That is justifiable, from a regulatory point of view, considering that the environmental benefits reflect the reduction externality, imputable to the sector, as a whole, in terms of emission reduction ceilings, whilst the other benefits are partially captured by the consumers who participate in the measures.

Fig. 2 presents the benefit/cost ratio variation when the different appraisal criteria adopted change in relation to the initial base. The consideration of alternative criteria substantially changes the benefit/cost ratio; in spite of such variations the ratio always maintains a value higher than one, the acceptance limit.

In Fig. 3 we assess the influence of the different criteria in the merit order of each measure. For each alternative valuation criteria the merit order obtained can be compared with the one established for the 2002-2004 regulatory period.

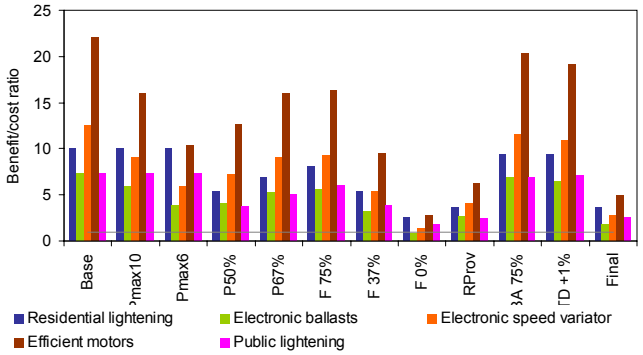

Fig. 2 Benefit/cost ratio of each measure according with different criteria.

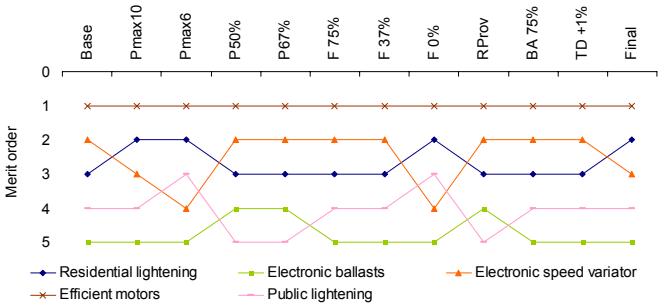

Fig. 3 Influence of economic criteria on the merit order of the measures.

The tariff impact of the measures changes considerably with the different economic criteria used. In the final hypothesis some measures represent less than 40% of the initial base value. The influence of the different criteria in the measures benefit/cost ratios is substantial and heterogeneous; nonetheless the merit order of the measures does not change substantially.

The benefit/cost ratio for the total of the DSM measures is presented in Fig. 4, together with the value of the costs and benefits to be recognized in the allowed revenues and thus paid by the consumers. If the base hypothesis for valuation is used consumer would pay in the tariffs 3,2 million euros for the program through the electricity tariffs. When the final hypotheses for valuation is adopt the cost drops to 1,0 million euros. Even though the program's ratio benefit/cost varies it stays always greater than one, including in the final hypotheses.

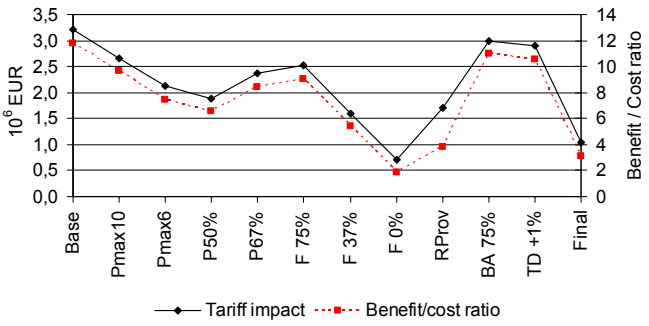

Fig. 4 Benefit/cost ratio and tariff impact for the sum of the measures on the program.

The economic criteria used for valuation prove to have a strong impact in determining the amount to be paid in the tariffs by the electricity consumers, i.e. they have great influence on the incentive received by the electricity distribution utility (acting has the regulated supplier) for the implementation of these programs.

As explained before the regulated supplier of electricity can implement these measures on a voluntary basis. As an incentive he receives in the tariffs all the amount spent plus half of the net benefit calculated according with the criteria discussed here. For the five measures we present the total cost of implementation for the supplier, which would be 0,5 million euros and considering the criteria established for the 2002-2004 regulatory period he would receive from consumers, via tariffs, 1 million euros as a compensation for implementing those measures. So, consumers would pay double the cost of implementing the DSM measures to the distribution utility (acting has the regulated supplier).

The result is tied to the existent regulatory and legal framework and can change when different examples of measures are chosen.

Even though the incentives to implement these type of DSM measures were that high, none was implemented during the regulatory period. During this period the distribution utility decided only to implement the so called intangible measures. Consisting of measures aimed at inform and educate consumers about the more efficient use of energy and also research studies about energy efficiency. These measures were recognized in the tariffs at their cost value; being considered that their intangible benefits equal the costs. The total amount recognized for the 3 years of the regulatory period was 1,1million euros, that represent 0,01% of the total amount paid to the regulated supplier by the consumers.

Fig. 5 presents the environmental impact of the program accumulated for the lifetime of the measures, both in terms of unit of energy saved and tons of avoided CO_2 emissions. Fig. 6 shows the economic unit value of the measures presented as example on this paper, in terms of saved energy and ton of avoided CO_2 emission.

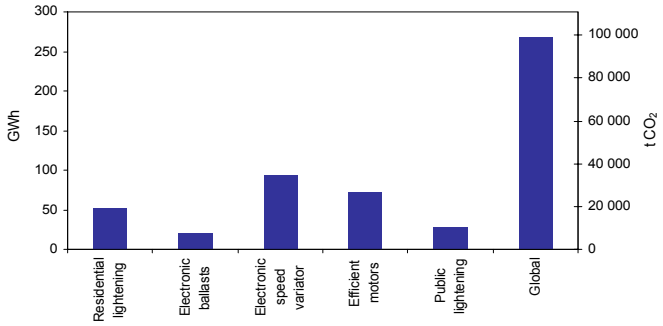

Fig. 5 Environmental benefit of the different measures (GWh saved and tCO_2 avoided).

The analysis of the results indicates that the environmental value for the program presented in this paper considering the economic valuing criteria adopted for the 2002-2004 regulatory period, is 3,9 €/MWh of electric energy saved that results in 10 €/tCO_2 avoided. Such a value is substantially inferior to the environmental premium given to renewable energy in the same period, that varied between 47 €/MWh for electricity produced by wind farms with average use under 2000 hours and 33 €/MWh for hydro power production, premiums which are established by the Government in Decree-Law n.º 339-C/2001, of 29 of December.

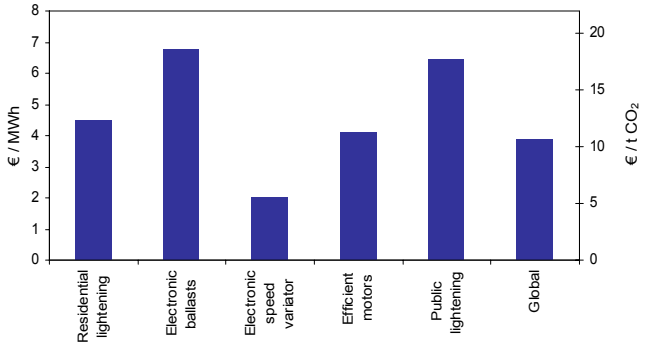

Fig. 6 Value of the environmental benefit of the different measures.

Taken in consideration the values presented, it is shown that the DSM measures are an effective solution to contribute to the green house gas emissions reduction, being an advantageous solution when compared with supply side measures. This stands even considering the high incentive rate attributed to the electricity distribution utility, that receives 1 million euros for every 0,5 million euros spent in DSM measures. The consideration of avoided investments in the network and avoided losses, due to the decrease in consumption, were not taken into account. Such consideration would increase the social interest of the DSM measures.

Finally, is important to stress that both the commitments assumed in the Kyoto Protocol and the goals established by the Government in the National Climate Change Program [10] regarding the reduction of green house gases enforce the principle of implementing the measures that exhibit less economic cost from a vast set of possibilities, that includes supply side and demand side measures and also network loss reduction programs.

IV. Conclusions

In this paper we discuss and compare different economic criteria to value DSM measures. The correct valuing of these measures is usually focused for the selection of the measures to be implemented. In the present case the valuing of the measures will have an impact on the amount incentive the electricity distributor utility receives in regulated tariffs. In the legal and regulatory framework that enables the distributor (acting has the regulated supplier) to voluntary implement different DSM measures, and receive from the regulated tariffs the costs of the measures plus half of the net benefit, the measures economic valuing methodology is of fundamental importance.

A set of typical DSM measures were chosen to be used as

examples and to perform simulations applying the different economic valuing criteria, observing the effect on the benefit/cost ratio, merit order of each measure and tariff impact.

The results show that the different criteria considered have a significant impact on the costs that electricity consumers pay through the tariffs and a relatively minor impact in terms of the merit order of the different measures. Thus changing the criteria among those discussed would not have a major impact on terms of project selection, but in turn, it can be determinant in terms of the amount of incentive given to each measure.

Finally, we use the criteria established for the 2002-2004 regulatory period to value the same program and we compared the resulting cost with the costs of other solutions to achieve the same policy objectives. It is demonstrated that, even with a high incentive given to electricity companies and paid by consumers, this type of measures achieves lower costs per unit of avoided CO_2 emissions than other supply side measures.

V. References

[1] ERSE, "Revisão dos Regulamentos do Sector Eléctrico – Documento de Discussão", ERSE, Lisboa, 2001. [Portuguese Only]. [Online]. Available: www.erse.pt

[2] ERSE, "Regulamento Tarifário", ERSE, Lisboa, 2001. [Portuguese Only]. [Online]. Available: www.erse.pt

[3] ADENE, Programa SAVE No. 4.1031/Z/98-267, "Gestão da Procura. Campanha de medições por utilização em 400 unidades de alojamento na União Europeia. Avaliação dos potenciais de economia de electricidade", ADENE, 2002. [Portuguese Only].

[4] A. Traça de Almeida, A. Cristina Rosa e F. Grilo Gonçalves, "Manual de Programas de DSM", Universidade de Coimbra, 2001. [Portuguese Only].

[5] EDP Distribuição Energia S.A. "Plano de Gestão da Procura", EDP Distribuição Energia S.A., Outubro de 2002. [Portuguese Only]

[6] ERSE, "Apreciação do Plano de Gestão da Procura da EDP Distribuição", ERSE, Lisboa, 2003. [Portuguese Only].

[7] The Carbon Trust, "Best Practice Programme", The Carbon Trust, United Kingdom, 2005.

[8] Copper Development Association "Good Practice Case Study 162", Copper Development Association, United Kingdom, 1992.

[9] A. Trindade, P. Roberto e V. Barroso, "A utilização racional de energia na iluminação pública em três municípios", Revista Energia, Nº4 ano XV (II Série), Lisboa (1999). [Portuguese Only].

[10] Presidência do Conselho de Ministros, "Plano Nacional para as Alterações Climáticas", Resolução do Conselho de Ministros n.º 119/2004, Diário da República (I Série - B). [Portuguese Only].

[11] M. Armstrong, S. Cowan e J. Vickers, "Regulatory Reform – Economic Analysis and British Experience", London, MIT Press, 1994.

[12] F. Kreith e R. West, "CRC Handbook of Energy Efficiency", CRC Press, E.U.A., 1997.

[13] ERSE, "Revisão da Estrutura Tarifária: 1ª Fase", ERSE, Lisboa, 2000. [Portuguese Only].

[14] ERSE, "Caracterização do Sector Eléctrico – Portugal Continental 2001 ERSE, Lisboa, 2002. [Portuguese Only].

[15] ERSE, "Parâmetros e Tarifas e Preços para a Energia Eléctrica e Outros Serviços em 2005", ERSE, Lisboa, 2004. [Portuguese Only]. [Online]. Available: www.erse.pt.

VI. Biographies

ERSE is the Portuguese Electricity and Natural Gas Regulatory Authority. The authors of this paper are with ERSE Tariffs and Prices Division.

Isabel Apolinário was born in Lisbon, Portugal, on October 29, 1973. She graduated in Economics, in 1996, and received her MSc Degree in Energy and Environment Economics in 2005, both from the Technical University of Lisbon - Instituto Superior de Economia e Gestão. She his with ERSE since1998 and her professional background includes the Portuguese Electricity Operator (EDP) and the Portuguese National Institute of Statistics, producing the Quarterly National Accounts. Her current interests are electricity and gas tariffs, economic regulation, efficiency and productivity, energy efficiency and market liberalization.

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António Leite Garcia was born in Porto, Portugal, on June 27, 1933. He graduated from University of Porto - Engineering Faculty, in Electrical Engineering (1956) and studied Nuclear Engineering, Institut de Sciences et Techniques Nucléaires de Saclay, in Paris (1958). He is adviser of the Portuguese Electricity Regulatory Authority, since 1998. His employment experience includes auditing (1985-98) and tariff and strategic plan activities (1976-85), at central directorate level, in Electricidade de Portugal, the Portuguese electricity company.

Paulo Oliveira was born in Lisbon, Portugal, on December 19, 1976. He graduated from the Technical University of Lisbon - Instituto Superior Técnico, Lisbon, in power engineering (1999). He is with ERSE since 2001 and his professional background includes the Portuguese Transmission System Operator, REN. His current interests are energy supply tariffs, energy efficiency, market liberalization and information systems.

Artur Trindade was born in Nampula, Mozambique, on May 13, 1971. He graduated from the Catholic University of Lisbon, in Economics (1994). He Received the M.A in Development Economics from the University of Kent at Canterbury (1995). He is with ERSE since 2000 and his professional background includes the Portuguese Energy Agency (ADENE), the Portuguese Secretary of State for Industry and Energy and lecturing undergraduate economics. His current research interests include economic regulation, energy efficiency, renewable energy and energy markets reform.

Pedro Verdelho was born in Porto, Portugal, on December 26, 1963. He received the Dipl. Ing., the M.S. and Ph.D. degrees from the Technical University of Lisbon-Instituto Superior Técnico, Lisboa, Portugal in 1987, 1990 and 1995, respectively, all in electrical engineering. He joined Instituto Superior Técnico in 1985. Since 1995 till 2002 he has been an Assistant Professor at the Universidade Técnica of Lisbon-Instituto Superior Técnico. Since 1985 he has been a research member of the Centro de Automática of the Technical University of Lisbon-Instituto Superior Técnico. In 1999 he joined the portuguese energy regulatory authority, Entidade Reguladora dos Serviços Energéticos, being responsible for the Tariff and Prices Division. His main interests include electricity and gas tariffs and prices, energy efficiency, economic regulation, power quality, power electronics, active power filters, reactive power compensation systems, variable speed drive and generator systems. He received the Meritorious Paper Award in 1996 from the IEEE Industrial Electronics Society.