

Promoting demand-side management and energy efficiency in Portugal

2 years of experience

I. Apolinário, C. Correia de Barros, H. Coutinho, L. Ferreira, B. Madeira, P. Oliveira, A. Trindade, P. Verdelho

Entidade Reguladora dos Serviços Energéticos (Energy Services Regulatory Authority), Lisbon, Portugal

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Abstract — ERSE has established a mechanism aimed at promoting efficiency in electricity consumption called PPEC, having a yearly (2007 and 2008) implementation budget of 10 million euros, representing 0,2% of final prices. PPEC consists of a tender mechanism, by which eligible promoters submit measures to improve electricity efficiency. These measures are selected through technical and economical evaluation criteria presented in this paper.

The benefits for the electricity sector and the environment from PPEC 2008 are much higher than the correspondent costs, with a ratio of 8:1 in the residential segment; 9:1 in the services segment and 7:1 in the industrial segment. From 2007 to 2008, the expected cumulative avoided consumption more than doubled from 390GWh / 144 455 tonCO₂ to 878GWh / 324 794 tonCO₂.

The costs per ton of CO₂ avoided (PPEC 2008: 9,2€/MWh; PPEC 2007: 21,2€/MWh) are much lower than the cost resulting from the implementation of equivalent measures in the supply side, such as the promotion of special regime generation (41,6€/MWh).

I. INTRODUCTION

The purpose of this paper is to run a balance of the two years experience of implementing PPEC (Plano de Promoção da Eficiência no Consumo de Energia Eléctrica) demonstrating the importance of this sort of measures, that act on the demand side, in meeting international and national objectives for CO₂ emissions reduction.

II. DEMAND-SIDE ELECTRICITY EFFICIENCY PLAN (PPEC)

The most effective way to promote energy efficiency is through the definition of tariffs that allow the recovery of costs associated with each and every activity of the electricity sector and by tariff structures and prices that reflect marginal or incremental costs. This methodology is incorporated in the Portuguese electricity tariff code. Nonetheless, environmental externalities not reflected in prices and the existence of barriers to the adoption of efficient behaviours justify the implementation of initiatives to foster energy efficiency.

Therefore, ERSE has developed a mechanism for promoting efficiency in electricity consumption (PPEC).

PPEC consists of a tender mechanism, by which eligible promoters (suppliers, network operators, consumers' rights associations, energy efficiency agencies, etc) submit initiatives to improve electricity efficiency in the industrial, services and household/residential sectors. The annual budget is 10 million euro and, as foreseen in the tariff code, that amount is supported through the Global Use of System Tariff, paid by all consumers.

PPEC comprises two types of measures:

- Tangible – installation of equipment with a level of efficiency superior to standard equipment on the market, therefore producing measurable consumption reductions. In Table I some examples of tangible measures are shown, as well as their technical characteristics.
- Intangible – disseminating information on energy efficient practices in order to promote a change in behaviours. An example of this kind of measures is energetic audits, information campaigns, seminars and conferences.

TABLE I
TECHNICAL CHARACTERISTICS OF TANGIBLE MEASURES (SOME EXAMPLES)

Measure	Assumptions
Residential lighting (Fluorescent Compact Lighting 18 W)	- Aimed for the household segment - Useful lifetime: 6 years - Annual consumption reduction: 62 kWh (relative to 75W incandescent light bulb)
Electronic ballasts	- Aimed for the services segment - Useful lifetime: 16 years - Annual consumption reduction: 63 kWh (relative to a ferromagnetic ballast and considering T8 bulbs of 36W)
Electronic speed variator (<=70KW)	- Aimed for the industrial segment - Useful lifetime: 15 years - Annual reduction in consumption: 25%

III. TECHNICAL AND ECONOMIC CRITERIA FOR EVALUATING ENERGY EFFICIENCY MEASURES

The measures are analysed and approved by means of a

competitive process and ranked according to pre-established rules, based on a cost-benefit analysis.

A. Evaluation criteria for energy efficiency tangible measures

In evaluating the tangible measures, first of all, the Social NPV (Net Present Value from a social perspective) is calculated as in (1). Measures with a negative NPV are excluded.

$$NPV = \sum_{t=0}^n \frac{B_{S_t} - C_{S_t}}{(1+i)^t} \quad (1)$$

where:

B_{S_t} Total benefits from the social point of view in year t

C_{S_t} Total costs from the social point of view in year t

i Discount rate

n Useful lifetime

The net social benefit (NBS) of each measure for each year is given by the following expression (2)

$$NBS = B_{S_t} - C_{S_t} = \Delta MgC + B_{ENV} - (CM_{part} + CM_{PPEC} + CM_{others}) \quad (2)$$

where:

ΔMgC is the avoided cost of supplying electricity (includes generation, transmission and distribution)

B_{ENV} is the avoided CO₂ emissions

CM_{part} , CM_{PPEC} , CM_{others} are the costs borne by the participants, PPEC and other entities.

The tangible measures' ranking process is done individually for each segment: industry, services and households, thus allowing for the funds to be distributed by all segments.

Measures with a positive NPV are then ranked according to the following technical and economic criteria:

(a1) benefit-cost proportional analysis – 25 points (3);

$$P_p = 25 \times \frac{RBC_p}{RBC_{max}} \quad (3)$$

where the weight of each measure (p) is proportional to its benefit-cost ratio (RBC), calculated in (5), up to 25 points, being 25 points given to the measure with the highest benefit-cost ratio.

(a2) benefit-cost ordered analysis – 25 points (4);

$$25 - (k-1) \times \frac{25}{n} \quad (4)$$

where:

n is the number of measures

k is the position of the measure in terms of RBC

The RBC is calculated accordingly to the following expression (5):

$$RBC = \frac{\sum_{t=0}^n \frac{B_{S_t}}{(1+i)^t}}{\sum_{t=0}^n \frac{C_{PPEC_t}}{(1+i)^t}} \quad (5)$$

where:

RBC Benefit-cost ratio

B_{S_t} Total benefits from the social point of view in year t

C_{PPEC_t} Total costs, from the PPEC point of view in year t

i Discount rate

n Useful lifetime

(b) equity (5 points) – evaluates the measure of equity considering the geographical scope and the way participants and suppliers are selected on the basis of a predefined set of questions;

(c) presentation quality (5 points) – evaluates the measure in terms of how clearly and objective it is presented and how well its assumptions are justified. It also evaluates the quality of its measuring and verification plan both on the basis of a predefined set of questions;

(d) scale risk (10 points) – evaluates the variation in average costs in each measure as a function of its execution rate (6);

$$IS_C = \left(\frac{CF + \sum_{i=1}^m C_{v_i}}{CF + \sum_{i=1}^n C_{v_i}} \right) - 1 \quad (6)$$

where:

IS_C Scale index

CF Fixed PPEC cost, i.e, does not depend on the number of interventions

C_{v_i} Unit variable PPEC cost of intervention i

m Number of interventions

n Half the interventions

The best ranked measure receives 10 points and the following are ranked as shown in (7)

$$10 \times \frac{IS_C}{IS_{C_{max}}} \quad (7)$$

where:

IS_C Sensibility index

$IS_{C_{max}}$ Maximum sensibility index in all the measures of a given segment

(e) ability to overcome market barriers and spillover effect (5 points) – evaluates measures in terms of its effectiveness in overcoming market barriers to its implementation and its capability in spreading out its effects on the basis of a predefined set of questions;

(f) innovation (5 points) – evaluates the degree of uncommonness of a measure and compensates innovative measures for its higher costs relatively to conventional measures on the basis of a predefined set of questions;

(g) weight of the investment in equipment in the total cost of the measure (10 points) – awards measures that maximize the direct investment in equipment rather the administrative or support costs (8);

$$ID = \frac{K}{CT} \quad (8)$$

where:

ID weight of the investment in equipment in the total

cost of the measure

K PPEC amount spent on acquiring the equipment

CT total costs

The best ranked measure receives 10 points and the following are ranked as shown in (9)

$$10 \times \frac{ID}{ID_{\max}} \quad (9)$$

where:

ID weight of the investment in equipment in the total cost of the measure

ID_{\max} Maximum weight of the investment in equipment in all the measures of a given segment

(h) **savings sustainability** (10 points) – awards measures that generate long lasting savings.

- Savings last up to 3 years: 3 points
- Savings last between 3 and 10 years: 1 point for each year
- Savings last more than 10 years: 10 points

In order to maximize the program's score the measures are selected accordingly to the following expression (10). The marginal measure is subject to budgetary cuts in order to meet and fulfill PPEC's budget.

$$\max_{i \in U_s} \sum f_i(A1, A2, B, C, D, E, F, G, H, Interv_i) \left\{ \sum_{i \in Ap_s} Cost_i^t \leq Budget_s \right.$$

where :

$$Cost_i^t = C_{Fix_i}^t + Interv_i \times c_{Var_i}^t \quad (10)$$

Where f_i is the score of measure i , from the total measures in segment s , considering the number of interventions $Interv_i$ that ensures that the cost restriction is met (the total cost of measures approved in segment s , Ap_s , should be comprised in its segment budget). The cost of each measure i corresponds to the sum of the fixed cost (C_{Fix}) and the variable cost (c_{Var}).

B. Evaluation criteria for energy efficiency intangible measures

Intangible measures are ranked according to the following criteria:

- (a) **presentation quality** – 20 points;
- (b) **equity** – 20 points;
- (c) **ability to overcome market barriers and spillover effect** – 20 points;
- (d) **innovation** – 20 points;
- (e) **experience in similar programs** – 20 points.

The number of interventions in intangible measures is not variable, however it is considered acceptable that the costs of the marginal measure be reduced up to 20% to meet the budget frontier.

C. Classification matrix applied to the non-metric criteria

The benefit-cost ratio, weight of the investment in equipment in the total cost of the measure and, savings sustainability are metric criteria, while the remaining are of a

non-metric nature. In order for the non-metric criteria to be objective, a classification matrix was created.

TABLE II
PRESENTATION QUALITY MATRIX

Question	Tangible	Intangible
Does the measure meet the information requirements in PPEC regulations (article 14)? For the i requirements, we have: 0xpts: if $i \leq 9$ (tangible); $i \leq 7$ (intangible) 1/3xpts: if $i = 10$ (tangible); $i = 8$ (intangible) 2/3xpts: if $i = 11/12$ (tangible); $i = 9$ (intangible) 1xpts: if $i \geq 13$ (tangible); $i \geq 10$ (intangible)	1 point	5 points
What is the average presentation quality of the measure? Low (0xpts); Medium (1/3xpts); High (2/3xpts); Very High (1xpts)	0,5 points	4 points
Is all the information necessary to calculate the ranking criteria submitted?	1 point	5 points
Are the indicators necessary to the application of the ranking criteria presented in a correct, clear and coherent manner?	0,5 points	Not applicable
Are the assumptions relating the costs of equipment, avoided consumptions and reference scenarios well supported?	1 point	Not applicable
Does the measure contain a cost-benefit analysis?	Not applicable	2 points
Does the measure present an adequate timetable of its stages?	0,5 points	4 points
Is the verification plan in line with the measures' objectives?	0,5 points	Not applicable
Total	5 points	20 points

TABLE III
EQUITY MATRIX

Question	Tangible	Intangible
Is consumer eligibility based solely on characteristics related to the consumption of the potential beneficiary?	1,25 points	Not applicable
Does the measure ensure non discriminative behaviors concerning the geographic location?	1,25 points	6 points
Do the promotional events ensure that all potential participants are considered?	1,25 points	4 points
Is there a market consultation before choosing the supplier of the services /equipments?	1,25 points	Not applicable
What is the relation between the cost of the measure and its effectiveness to overcome market barriers?	Not applicable	10 points
Total	5 points	20 points

TABLE IV
ABILITY TO OVERCOME MARKET BARRIERS AND SPILLOVER EFFECT MATRIX

Question	Tangible	Intangible
Which of the following market failures does the measure help overcome? Higher cost; Lack of information; Difficult access to financing; Insufficient distribution network; Agency problems; Existence of negative externalities not included in	3 points	8 points

the price What is the effectiveness of the measure in overcoming the above mentioned barriers? Low (0xpts); Medium (1/3xpts); High (2/3xpts); Very High (1xpts)		
What is the probability of the measure producing tangible effects in the short / medium term? Low (0xpts); Medium (1/3xpts); High (2/3xpts); Very High (1xpts)	Not applicable	8 points
Are there durable information supports?	0,5 points	2 points
Does the measure make the beneficiaries accountable for results?	0,5 points	1 point
Does the measure help to create competences among participants?	Not applicable	1 point
Does the measure promote awareness among participants?	0,5 points	Not applicable
Does the measure have impact in consumers other than the participants?	0,5 points	Not applicable
Total	5 points	20 points

TABLE V
INNOVATION MATRIX

Question	Tangible	Intangible
How innovative is the measure in the context of energy efficiency promotion in Portugal? Low (0xpts); Medium (1/3xpts); High (2/3xpts); Very High (1xpts)	2,5 points	14 points
How innovative is the measure in what concerns consumers' involvement? Low (0xpts); Medium (1/3xpts); High (2/3xpts); Very High (1xpts)	0,5 points	6 points
Is the equipment's technology considered emergent?	0,5 points	Not applicable
Is there a concern to minimize environmental impacts?	1,5 points	Not applicable
Total	5 points	20 points

TABLE VI
EXPERIENCE MATRIX

Question	Tangible	Intangible
Is the promoter's or his partners' experience relevant for the implementation of the measure? Low (0xpts); Medium (1/3xpts); High (2/3xpts); Very High (1xpts)	Not applicable	14 points
What is the relevance of the partnerships for the success of the measure and its implementation? Low (0xpts); Medium (1/3xpts); High (2/3xpts); Very High (1xpts)	Not applicable	6 points
Total	0 points	20 points

The PPEC regulations [5] defines some of the parameters used to evaluate the measures like, the discount rate applicable to the benefits and costs, the avoided unit costs, the value of the avoided CO₂ emissions, and the useful life of the equipments. Some parameters like the avoided consumption of the equipments were adjusted considering well justified proposals received from the promoters.

IV. IMPACTS AND BENEFITS OF THE ENERGY EFFICIENCY MEASURES APPROVED BY PPEC

The first PPEC - PPEC 2007, comprise measures to be implemented in 2007, 2008 and 2009. The second PPEC -

PPEC 2008, relates to measures to be implemented in 2008, 2009 and 2010.

Fig. 1 depicts the array of measures candidate to PPEC 2008 and the measures approved by type of technology. It can be seen that the amount of candidate measures is much higher than the approved amount. So a very competitive contest was achieved.

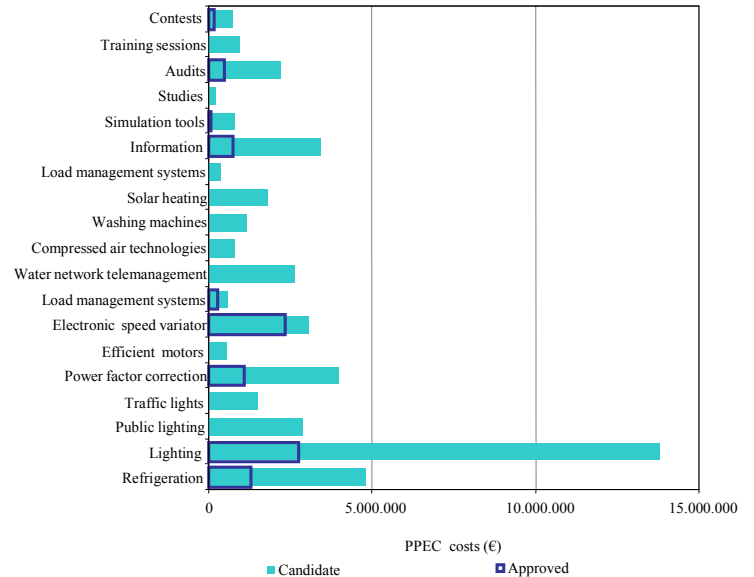


Fig. 1. Measures candidate to PPEC 2008 and measures approved

Fig. 2, below, shows that PPEC 2008 was more competitive than PPEC 2007 in terms of candidate amounts, while Fig. 3 compares PPEC 2007 with PPEC 2008 in terms of the number of candidate measures and total amounts. In 2008, 131 measures valued in 46,2 million euros were submitted to the contest, while only the best measures valuing 9,3 million euros could be approved.

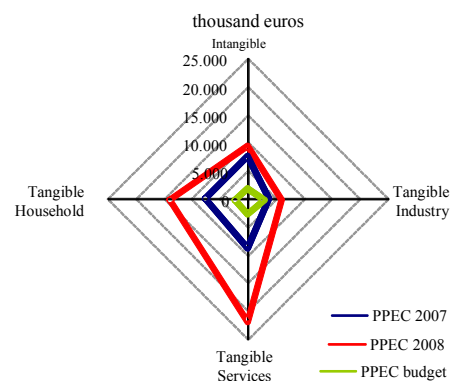


Fig. 2. Measures candidate to PPEC 2007 and PPEC 2008 and measures approved by contest



Fig. 3. Number and amount of measures candidate to PPEC 2007 and PPEC 2008

Fig. 4 forecast expected measurable impacts for the implementation of PPEC 2007 and PPEC 2008. From 2007 to 2008, the expected cumulative avoided consumption from measures approved more than doubled (390 GWh / 144 455 ton CO₂ to 878 GWh / 324 794 ton CO₂). This is the result of the higher benefit/cost ratio of PPEC 2008 compared to PPEC 2007.

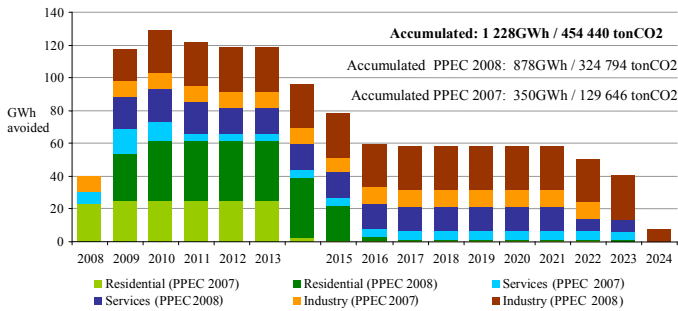


Fig. 4. Annual avoided consumption from PPEC 2007 and PPEC 2008 tangible measures

Measures approved in PPEC 2007 have a unit cost of 21,2€/MWh avoided, which compares to a lower value of 9,2€/MWh avoided in the measures approved by PPEC 2008 (Fig. 5 and Fig. 6).

The measures approved are subject to auditing in order to verify its degree of compliance in terms of costs, objectives and avoided consumption.

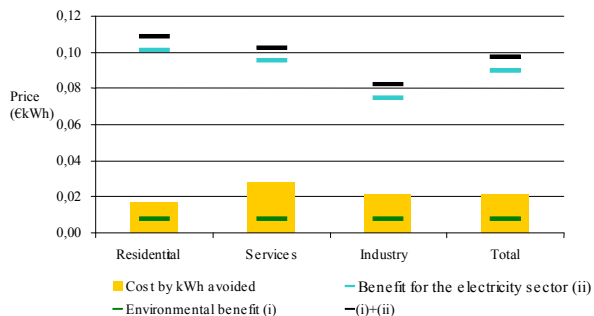


Fig. 5. Benefits and costs from PPEC 2007 tangible measures per unit of consumption avoided

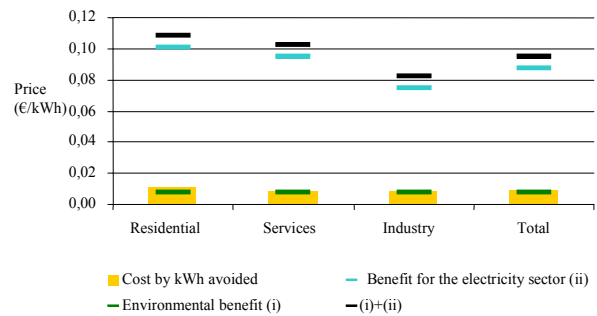


Fig. 6. Benefits and costs from PPEC 2008 tangible measures per unit of consumption avoided

In any scenario the unit costs of consumption avoided are significantly lower than the cost resulting from the implementation of supply side equivalent measures, such as the premiums given to special regime generation (41,6 €/MWh).

The premium paid to special regime generation is justified by the goal of reducing CO₂ emissions and diversifying sources of supply. Demand side management tools, like PPEC, proves to be competitive and serve the same purposes as special regime generation. Although both solutions have other virtues, it is clear that their assessment should be made in parallel.

Fig. 7 illustrates the cost and the social benefit per consumer estimated for PPEC 2007 and PPEC 2008. The analysis clearly shows that in only one year the efficiency of the measures approved increased. In fact, in any given segment or year, expected benefits clearly outweigh expected costs, up to a factor of 9 in PPEC 2008 – services segment.

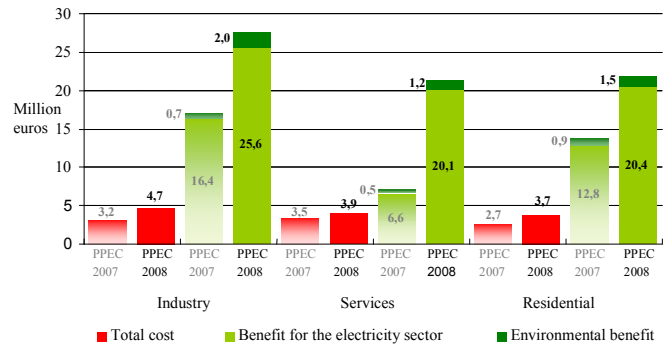


Fig. 7. Costs and social benefits per consumer from measures in PPEC 2007 and PPEC 2008

V. CONCLUSIONS

The paper presents 2 years' experience in promoting demand-side management and energy efficiency in the framework of the electricity regulation. The instrument conceived by ERSE to improve electricity efficiency in the demand side is called PPEC (Plano de Promoção da Eficiência no Consumo).

PPEC consists of a tender mechanism, by which eligible promoters submit measures to improve electricity efficiency. These measures are selected through an objective technical and economical evaluation criteria presented in the paper.

For PPEC 2008, 131 measures valued in 46,2 million euros were submitted to the contest, knowing that only the best measures worth 9,3 million euros would be approved. The expected cumulative avoided consumption is 878 GWh representing 324 794 tonCO₂. The expected measurable benefits to be recovered are 72 million euros leading to a global benefit/cost ratio of 7,7.

The analysis of the forecasted PPEC impacts encourages the adoption of competitive demand side management tools, such as PPEC, as a regulatory tool to foster energy efficiency in consumption and CO₂ emissions reduction.

VI. ACKNOWLEDGMENT

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The opinions, interpretations and conclusions presented in this paper do not necessarily reflect the official position of ERSE.

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VIII. BIOGRAPHIES

I. Apolinário (b. 1973) 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 is with ERSE since 1998 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.

C. Correia de Barros (b. 1974) graduated from the Technical University of Lisbon – Instituto Superior Técnico, Lisbon, in Electrical Engineering (1998). She is with ERSE since 1999 and her professional background includes the General Directorate for Energy end geology (DGEG). Her current

interests are electricity and gas tariffs, energy efficiency and market liberalization.

H. Coutinho (b. 1978) graduated in mechanical engineering in 2003, and he got the M.Sc. degree in mechanical engineering, Energy profile, in 2006, both from the Technical University of Lisbon – Instituto Superior Técnico, Portugal. He is with ERSE since 2005 and his background includes Computational Fluid dynamics (CFD) and project analysis of micro Combined Heat and Power (CHP) plants. His current research interests include energy supply tariffs, energy efficiency, market liberalization and renewable energy systems.

L. Ferreira (b. 1978) graduated in Management in 2001 from the Universidade Nova de Lisboa. She is with ERSE since 2007 and her professional background includes the Portuguese Electricity Operator (EDP). Her current interests are electricity and gas tariffs, economic regulation, efficiency and productivity, energy efficiency and market liberalization.

B. Madeira (b.1978) graduated from the Technical University of Lisbon - Instituto Superior Técnico, Lisbon, in power engineering (2003). He is with ERSE since 2007 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.

P. Oliveira (b.1976) 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.

A. Trindade (b. 1971) 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.

P. Verdelho (b. 1963) 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 till 2007 he was a research member of the Centro de Automática of the Technical University of Lisbon. Since 2007 he has been a research member of Centro para a Inovação em Engenharia Electrotécnica e Energia from 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 published more than 100 papers having received the 1996 IEEE Industrial Electronics Society Meritorious Paper Award.