PRICING POLICY TOWARDS ELECTRICITY INTENSIVE INDUSTRIES IN GREECE

ΟΙΚΟΝΟΜΙΚΟ ΠΑΝΕΠΙΣΤΗΜΙΟ ΑΘΗΝΩΝ
ΒΙΒΛΙΟΘΗΚΗ

Panayotis Miliotis*

This paper examines the problem of pricing bulk electricity consumers in countries with limited energy resources. The aluminium industry in Greece is taken as a particular case study. The specific problems arising when large consumers are connected to a national grid are discussed and the subsidy resulting under different pricing approaches is estimated. This work provides useful basic information for assessing the over-all impact of this industry to the greek economy.

Introduction

1. Greece is a country with limited energy resources: its basic domestic energy resources are lignite and hydro. In 1979, the electricity-generating interconnected system included a 1,385 MW capacity of hydro plants with an average hydraulicity of 3,680 GWh per year (i.e. the mean annual energy generation), and 3,123 MW of thermal units of which 1,813 MW were lignite-fired and 1,160 MW oil-fired. The system also included a dual unit of 150 MW fuelled by oil and/or lignite and approximately 120 MWs of gas turbines.

2. The expansion programme for the period 1980-1989 included a total of 5,014 MW of thermal units comprising the following: 12 units of 300 MW each (a total of 3,600 MW will be lignite-fired, based on domestic lignite reserves); 700 MW (2×350) coal-fired, based on imported coal; one 600-MW unit (the first nuclear unit of the system); and 2×57 MW diesel gas turbines with limited operation. The two coal units are envisaged as coming into operation in 1985, and the nuclear power plant in 1989/1990 (see footnote 1).

3. As a result, according to present plans, all power units corresponding to known lignite reserves are expected to have been constructed by 1989. In effect, this means that lignite resources will be depleted at the fastest possible rate, and more rapid expansion would not therefore be

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realistic in both engineering and managerial terms. On the other hand, building more units on the basis of known lignite reserves (deposits) would have the effect of shortening the lifetime of both fields and generating units, and would not therefore be economical. The basic reason for such rapid utilization of domestic lignite reserves is that lignite is the cheapest source for generating basic-load electricity both in terms of total cost and in terms of foreign expenditure required.

4. As to hydro resources, the expansion programmes includes 2,914 MW of hydro units yielding 4,285.1 GWh per year under average hydraulicity conditions and 2,992.8 GWh under «critical» (i.e. low hydraulicity) conditions. By its very nature, the hydro potential in Greece — at least, for most sites — renders the hydro plants economical for operation at peak hours only; most of the sites are suitable for providing an average of 1,000-1,200 KWh per year per installed KW under cri-critical hydrological conditions.

TABLE 1

Expected synthesis of the fuel mix in future years
(*in GWh*)

	1980	1981	1984		1986		1989	
Total net demand	20 800	22 200	27 600	(24 420)	32 500	(27 580)	40 900	(33 310)
Oil	7 250	5 812	7 512	(4 402)	1 321	(1 092)	847	(1 375)
Lignite	10 234	13 600	16 826	(16 868)	24 546	(22 926)	31 306	(27 170)
Hydro	3 042	2 788	3 262	(3 150)	4 123	(3 504)	5 022	(4 184)
Coal					2 510	(—)	3 257	(—)
Nuclear							322	(—)
Pumping							146	(581)

Source : Public Power Corporation (PPC).

5. It is expected therefore that, according to present plans, 3,680 + 4,285 = 7,965 GWh of the 15,000 GWh of the economically-usable potential will have been exploited by 1990. The remaining (approximately) 7,000 GWh of the hydro potential of necessity apply to the less favourable sites, from the economic point of view, and can thus be used for peak loads only. The present programme makes provision for sufficient number of thermal units to meet both base and intermediate-load demand and, at the same time, for substitution of oil to the maxi-

mum possible extent during the next nine years. (See table 1 for a projected synthesis of generated electricity). [1]

6. From the above, the following conclusions may be derived. Since hydro plants use all available water, generation from lignite cannot be further increased and, currently, a comparatively large amount of electricity generation is by means of oil, any increase in the Public Power Corporation's load above the growth forecast would entail further imports of oil in the short term (during the next five years) and imports of some other kinds of energy (especially coal or nuclear) in the medium and long term. In view of Greece's limited and exhaustible energy resources, the development of electricity-intensive industries has accelerated the utilization of imported energy forms (oil, nuclear and coal) within the electricity generating system.

7. Concerning steam coal electricity generation, transport costs constitute a significant component for Greece— unlike other countries which are rich in coal reserves. In addition, the most expensive and complex parts of the necessary equipment must be imported. For nuclear power plants, inadequate technological development at the national level results in higher nuclear costs than in countries with already-developed nuclear technologies. In both instances, therefore, Greece has a comparative cost disadvantage *vis-à-vis* countries either rich in coal reserves or with developed nuclear technologies for meeting future electricity demand.

8. Its hydro and lignite resources, although valuable, do not give Greece any relative cost advantage over other countries for meeting new uses of electricity. Moreover, any implicit subsidy regarding electricity use by industry in the form of electricity prices which are below marginal costs (electricity generation replacement costs) is in effect a subsidy on energy imports (oil, coal or nuclear). If industry needs to be subsidized, it might be better to subsidize those activities that result in a high domestic value added — such as manpower and skills — rather than imports of energy, so that economy in energy use would be encouraged and energy-intensive industries would be attracted only if they at the same time intensively used some of the abundant domestic resources.

9. In the case of the alumina-aluminium plant in Greece, the «overwhelming importance of foreign capital, material inputs and electric power in the production of alumina and aluminium ingot and the correspondingly small importance of labour, taxes and other domestic factors

of production means that the real domestic value added may be quite small in relation to the total value of output»[1].

Thus, greater participation by domestic factors of production could be achieved through successful development of a strong and economically viable aluminium processing industry.

Scarcity of domestic energy recourses, and electricity tariffs

10. In view of Greece's limited domestic energy resources, the usual pricing approach — i.e. to base the level of tariffs on accounting or traditional costs — is short sighted since it fails to take into account

TABLE 2

Generation and transmission costs
(per KWh)

Year	Gross drachmas/KWh	Net[1] drachmas/KWh
1969	0.3199	0.3351
1970	0.3289	0.3447
1971	0.3093	0.3241
1972	0.3960	0.4132
1973	0.4757	0.4977
1974	0.6114	0.64
1975	0.8001	0.8358
1976	0.8911	0.9287
1977	0.99	1.034
1978	1.037	1.075
1979	1.193	1.237

1) Including the cost of transmission and transformation losses of approximately 4.05 per cent.

1. The figures in paragraphs 1 through 9 are based on the 1980 provisional expansion programme of the Public Power Corporation (PPC). As a result of increasing electricity costs and prices and of the prevailing economic recession, electricity demand forecasts have been revised downwards in the 1981 PPC programme from an average annual rate of growth of 7 per cent to 5.5 per cent for the period 1981-1990. This has been matched by a downward revision of the expansion plan for imported energy forms. The installation of nuclear and coal units is expected to take place after 1990, whilst at the same time the role of oil in electricity generation will be restricted to a minimum level, (Revised figures appear in brackets in table 1.).

that lignite reserves will eventually be exhausted and «replaced» by a more expensive fuel (oil, nuclear or coal). In one sence, this encourages electricity use at a price lower than the long-run costs and therefore «values» electricity (and domestic resources) without considering the long-run effects. Consequently, one way of measuring the scarcity value of domestic energy resources is to price energy at its long-run marginal cost. Such a forward-looking approach then provides reasonable energy costs for any electricity-intensive project evaluation.

11. When comparing average with marginal costs of the Greek electricity-generating interconnected system, two periods should be considered: one, during the years 1950-1972, when cheap oil and economies of scale involved in the system's expansion resulted in marginal costs being below average costs; and, the second, from 1972 onwards, when the increases in oil prices, other energy factors in general and no apparent further economies of scale in the system's expansion brought the average cost below the marginal cost. As a result, whilst before 1972 marginal cost considerations favoured lower (reduced) electricity prices for bulk consumers, the same forward-looking marginal-cost reasoning when applied after 1972 indicates that lower energy prices would show a downward trend compared with future costs.

Pricing policy towards large consumers in Greece

12. In an attempt to achieve high growth rates during the past twenty years, government policy has always favoured subsidised electricity for industrial consumers. In this section, the pricing policy that has been adopted by the State-controlled Public Power Corporation (PPC) towards electricity-intensive industries is briefly discusesd and some figures are given concerning the subsidy involved.

13. Electricity-intensive industries are almost all high-voltage (150 KV) consumers. Since 1966 there has been one high-voltage tariff (known as the A-150 tariff) that applies to practically all high-voltage consumers. The A-150 average price (per kwh) depends mainly on the utilization factor and on the relation of subscribed demand to actual demand. Briefly, the A-150 is a two-part average-cost-based tariff, i.e. a demand rate based on subscribed demand, partly graded according to the level of demand, and an energy charge calculated in steps. Marginal costs are only partly reflected in the A-150 tariff to the extent that lignite prices include a scarcity value which is associated with the re-

placement cost of lignite and that the fuel escalation clause reflects also the increasing price of oil.[5]

TABLE 3

High voltage consumers[1]

Year	Aluminium (Aluminium de Grèce)	Nickel (LARCO)*	Average price paid by other high voltage consumers
1969	0.13158	0.358	
1970	0.13158	0.329	0.351
1971	0.13158	0.315	0.347
1972	0.13611	0.339	0.3646
1973	0.1355	0.399	0.44
1974	0.13611	0.488	0.5328
1975	0.293	0.647	0.6918
1976	0.334	0.333	0.782
1977	0.35746	0.35053	0.829
1978	0.393	0.444	0.959
1979	0.46098	0.44443	1.24

1) Aluminium supply voltage is 15 KV

* Until 1975 LARCO was priced according to the A-150 tariff and its electricity bill was partly covered by a government grant the amount of which is unknown.

14. Apart from the A-150 high-voltage tariff, there are two special tariffs for the two largest consumers: one for Aluminium de Grèce which involves two separate parts each of 130MW, and one for LARCO (the nickel industry). Given the almost constant demand of these two bulk consumers, their tariffs, for purposes of comparison, may be considered equivalent to a single KWh price. Table 3 indicates the KWh price paid by Aluminium de Grèce and by LARCO, and the «average» KWh prices paid by all other A-150 users.

Power contracts for smelters; a history of negotiations: the Greek case

15. In the first agreement between the Public Power Corporation and Aluminium de Grèce in 1960, the electricity price for the aluminium smelter was fixed at 3.1 mills per kwh for the first sixteen years of the contract and was then raised to 3.6 mills per kwh for the remaining

thirty-four years of the contract, which started on 1 July 1964 and is due to end on 30 June 2014. The original agreement was revised, after a two-year renegotiation process, in 1966; and the new energy base price was set at 4.375 mills. At the same time, an escalation formula was established by which a (relatively smaller) proportion of the base price would escalate according to officially-published international aluminium prices. The 1966 renegotiated tariff was also applied to demand for subsequent extensions of the smelter's capacity. By 1974, subscribed demand had reached a level of 260 MW.

16. As a result of the energy price explosion in 1973, aluminium electricity tariffs were again renegotiated in 1975. This time the electricity contract was divided into two parts (tariffs) — the first relating to the original part of the smelter with a subscribed demand of 130 MW, and the second to its extension with a subscribed demand of another 130 MW.

17. For the first part, the 1966 reegotiated tariff renmained virtually unchanged; for the second part, the base price was substantially increased to 13 mills. The escalation formula for the second part has a stronger link with cost and price changes; and a smaller (than in the first case) proportion of the base price remains constant. The remaining proportion escalates partly according to fuel costs (mainly based on domestic lignite resources) and partly according to officially-published international aluminium prices. The logic of a three-part escalation formula of this kind, as in the second tariff, may be that the constant part of the base price relates to existing hydro capacity at the time the smelter was built, whilst the remaining two escalating parts reflect, on the one hand, generally increasing fuel costs and, on the other hand, prevailing conditions in the international aluminium ingot market.

18. The contract also includes a clause that allows for renegotiation of tariffs every eight years by possible redefinitions of base prices and escalation formulae, in cases where significant changes occuring in the meantime had brought existing tariffs into conflict with the initial intentions of the two sides[2].

2. A new provisional agreement was reached between the Company and the Government of Greece in April 1981. According to press reports, Aluminium de Grèce intends to make an additional contribution towards covering the cost of electricity supplies for the years 1980, 1981 and 1982. (A revision of the power contract is due in 1982). As stated in the Company's 1980 annual report, this additional contribution, termed «circumstantial contribution to the national energy programme», amounted to US $ 10.7 million. If this amount is added to the Company's electricity

19. Certain conclusions can be drawn after comparing the two tariffs. The first tariff, that has remained very close to the 1966 agreement, demonstrates difficulty on the part of the Government to deviate from the initial agreement signed. At the same time, however, the Government's reluctance to pursue a harder line (that might lead to breaking the agreement) would seem to indicate its belief that the company's presence in the country makes a positive over-all contribution to economic growth at the national level.

20. The second tariff of the power contract demonstrates that aluminium companies are prepared to pay higher electricity prices provided that these are reflected in the prevailing international market conditions and that increased prices are considered as an essential contribution towards covering increasing electricity-generating costs.

21. It is interesting to note the division of the power contract into two separate tariffs rather than an equivalent «average» tariff. A possible explanation is that this reflects the company's intention to use the initial agreement as a starting point each time the power contract is renegotiated.

22. It may also be noted that the tariff of the other electricity-intensive industry (LARCO) was renegotiated in 1975: this resulted in a base price equivalent to the «average» base price allotted to the aluminium industry and an escalation formula similar to the one described in paragraph 17 above. The LARCO contract, however, has a shorter duration period.

The electricity subsidy problem

The nature of the problem

23. The problem of subsidising electricity in power contracts for aluminium smelters (and in general for bulk electricity consumers) is worldwide. It involves either offering electricity at a price which does not cover its traditional (average) cost or pricing electricity unrealistically in view of its alternative uses.

24. There is a dual motivation for offering reduced prices to bulk electricity consumers: first, a bulk electricity consumer incurs a lower-than-average unit cost within the system and, second, generally electri-

bill, the kwh price paid by the Company for the year 1980 is estimated to be 0.914 drachmas copmared with 0.460 drachmas for the year 1979.

city-intensive industries are expected to contribute to the overall development of the country. Estimating the cost that a bulk consumer incurs in the system (and thus the subsidy that a given pricing policy involves) is a prerequisite for assessing the industry's contribution to national economic growth.

25. In order to obtain an estimate of the subsidy that a given pricing policy involves, certain cost assumptions are necessary. More particularly, in those cases where a consumer is connected to the national grid (as in Greece) it is even more difficult to estimate the cost of electricity supplies to the consumer since the following factors lead to a deviation from the system's average generation and transmission (unit) costs.

26. First, there is an almost constant power demand by the aluminium ingot industry resulting in high load factors, and the industry should not, in principle, be charged with the cost of 'peaking' effects. The reasoning is that a consumer with uniform demand is not responsible for creating a peak in the sense that, if all other consumers had the same load characteristics, there would not be a peak in the system. However, once a peak exists in the system, a consumer with uniform demand definitely participates in it, whilst other 'peaking' consumers show some demand diversity which varies according to the consumer type.

27. Thus, if it its accepted that a peak is a given, undesirable feature of the system which should be eliminated (and that this view is one resulting in optimal operation and expansion of the system) then every customer who contributes to a peak should be penalized. This might be carried out by means of a time-of-day metering pricing system that reflects the marginal cost structure.

28. Second, the strict supply conditions that aluminium companies demand involve additional costs which are difficult to measure since they are not usually placed within a predefined reserve generation margin for one particular customer but, rather, relate to the system as a whole. Security of supply is achieved in such cases by granting priority of supplies over other customers in the event of a power failure. These are costs of a mainly qualitative nature.

29. Reliability costs are relatively high for the Greek system which includes hydro plants with a somewhat uncertain annual output and thus requires relatively high reserve margins. Both peaking costs and security of supply costs involve mainly power (and not energy) costs.

30. In general, the costs that a large consumer incurs in an interconnected system are not easily measurable. One approach is to compare

system costs of the present system with those of a hypothetical system that would have resulted if the consumer had not been included. The time-span of the comparison should be the consumer's entire lifetime. A simpler approach might be to charge the consumer with the average system costs taking into account the consumer's particular characteristics.

31. Thus, two established methods may be used for estimating the above costs (and, hence, the magnitude of a subsidy): a marginal cost approach and a traditional (average) cost approach. The former has the advantage of being forward-looking, it is particularly useful in inctances where energy resources are limited and it results in the fact that energy is not unrealistically priced. The average cost approach is somewhat backward-looking, and better reflects the cost conditions at the time when the consumer was connected to the system; it is more closely related to the accounting cost but not to the opportunity cost of resources used or saved. Marginal costs would therefore seem to be the ones that should be used, especially in countries with limited energy resources, to estimate subsidies. Average costs are, in a sense, a ceilling of achievement when negotiating aluminium smelter contracts.

Subsidy estimations

32. To obtain greater insight into the quantitative aspects of the subsidy involved in one particular case: – that of Aluminium de Grèce, the largest single electricity consumer in Greece — the KWh cost for a consumer with an installed capacity of 260 MW and an annual energy consumption of 2,100 GWh (the same load characteristics as Aluminium de Grèce) was estimated employing three different pricing approaches: two based on average cost data and one on marginal cost considerations. The value of working out different pricing approaches is that the sensitivity of the subsidy to one particular pricing method becomes more clear.

33. *Average cost estimations.* The average generation and transmission costs for the whole system are shown in table 4, column 1. A rough estimate assumes that, on average-cost consideration, a consumer with the characteristics described above should be charged with 80 per cent of the average system cost. The resulting KWh cost is shown in table 4, column 2.

34. To check these rough estimates, two alternatives pricing approaches were employed. The first was the A-150 tariff that is applied to all «other» bulk electricity consumers: the results of this approach are shown in column 3 of table 4. The second approach was to construct,

using PPC published data, a simple two-part tariff of which the first part included a fixed-cost (mainly capacity) component and the second part included a variable-cost (mainly fuel) component. The resulting KWh cost is shown in column 4 of table 4.

35. *Marginal cost estimations.* No figures are available for an estimate of the marginal costs on an annual basis. A simple computation from 1976 data showed that a cuctomer with uniform demand (100 per cent load factor), if the estimation is on a marginal cost basis, should pay 1.1 drachmas per KWh.

TABLE 4

Subsidy estimation
(in drachmas/KWh)

Year	Generation and transmission costs	Rough cost estimation	A-150 pricing	Two-part pricing
1970	0.3447	0.275		
1971	0.3241	0.259		
1972	0.4132	0.33		
1973	0.4977	0.398		
1974	0.64	0.512		
1975	0.8358	0.664	0.60	
1976	0.9287	0.743	0.68	0.62
1977	1.034	0.827	0.7	0.765
1978	1.079	0.860	0.82	0.847
1979	1.237	0.989	1.05	1.02

36. A rough estimate of the electricity-generation replacement cost, which is in effect equivalent to the cost of using electricity based on-exhaustible resources, may be obtained from available figures concerning the KWh cost of nuclear and coal plants. For comparative purposes, 1979 data have been used: coal plant: complete KWh cost 1.5 drachmas, based on a capital cost of $750/KW and fuel cost of $55/ton; nuclear plant: complete KWh cost 1.5 drachmas, based on a capital cost of $1,400/KW and fuel cost 8 mills per KWh. These figures are, however, estimates only and may be considered as conservative, as much as they have been assumed to be in the lower range of expected costs.

37. The following comments are applicable to the KWh cost computations reported above.

(a) the cost difference between average and marginal cost is that the former is largely based on lignite and the later is based on oil.

(b) Since in the aluminium power contracts described in paragraphs 15-22 above, the escalation formula includes a constant factor, the overall elasticity of the electricity price with regard to generating costs is less than one — leading to increasingly higher subsidies each year.

TABLE 5

Electricity consumption pattern by Aluminium de Grèce

Year	Installed capacity *(MW)*	Load factor *(percentage)*
1970	150–155	99.4
1971	260	79.8
1972	260	85.0
1973	260	93.3
1974	260	97.1
1975	260	90.9
1976	260	91.7
1977	260	91.5
1978	260	100.1

(c) The cost of more stringent supply requirements was not taken into account when the A-150 tariff was applied.

(d) The higher the part of the KWh cost corresponding to the variable (mainly fuel) cost in relation to the part that corresponds to the fixed (mainly capacity) cost, the closer becomes the KWh cost of the two-part tariff to the average KWh cost of the total system. This should be apparent since the importance of using installed capacity more efficienctly, as in the case of uniform demand, becomes less significant.

(e) Since the cost figures reported above are based on PPC data, they do not reflect electricity costs at the national level, unless the additional assumption is made that the oil consumed by the PPC has been correctly priced.

38. While in recent years there has been no discrimination in favour of the PPC as a customer, the Greek pricing system has favoured heavy fuel oil, as shown by the fact that, when recovering the total cost of oil imports, a burden relatively heavier than that in other countries has been placed on light oil products. For example, the pre-tax ratio of fuel oil to premium gasoline is 0.39 for Greece, 0.48 for France, 0.57 for the United Kingdom, and 0.63 for Italy. Moreover, heavy fuel oil incurs virtually no tax in Greece, whilst it is lightly taxed in other European countries.

Conclusions

39. Greece is a country with limited domestic energy resources — a situation resulting in over-high electricity-generating costs. Electricity subsidies for energy-intensive industries are, therefore, very high and it is important for the country to obtain best possible terms each time a contract is renegotiated. But efficient negotiatiations require systematic collection of information on the terms and renegotiation procedures of other, and similar, contracts — a difficult task since many of the countries concerned have proved unwilling, for various reasons, to disclose the relevant information sought.

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