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INCENTIVES FOR DECENTRALISED ENERGY SYSTEMS PROPOSALS FOR THE DEVELOPMENT OF EFFECTIVE INCENTIVES IN GREECE

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Abstract

The introduction of a new legislative framework for power generation by private investors provides a good opportunity for a more efficient policy in the renewable energy sources' sector and the decentralised energy production. However, as the example of the recently introduced Greek legislation shows, it is necessary to establish a system of incentives, beneficiary both for the national economy and the private investor, if renewable energy sources are to achieve the ambitious goal set by the E.U. for a 5% participation in the primary energy production.

The results presented in the present paper are drawn from a research project, that has dealt with the most wides read energy systems in Greece, which are to satisfactory extent representative for the Mediterranean area, and led to the proposal of more efficient incentives. (JEL Classification: Q48)

1. Introduction - The Case of decentralised energy systems

The legislative framework for incentives valid nowadays in Greece has its origins in 1982. It expresses two main governmental aims: to enhance regional investments and to support specific production branches, in particular activities

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in the industrial sector. It has been revised in 1994 and, as the introductory study of the legislative act 2234/94 stated, one of the main difficulties that occured over that last 15 years was the fact that regional criteria overruled a branch orientated policy. In order for the Greek state to be effective in developing decentralised, branch-orientated financial activities it has to be able to evaluate their contribution to the national economy in the first place. Only then will it be possible to create incentives that will support investment initiatives towards viable production units. Hence, a complete methodology is necessary for drawing up and evaluating the incentives leading to specific economic goals, considering the particularities of the Greek economy.

In this aspect, the Department of Industrial Management, at the Faculty of Mechanical Engineering at the Aristotle University of Thessaloniki submitted a proposal to the General Secretariat for Research and Technology in 1991. It concerned the determination of incentives that would effectively support the development of decentralised energy production systems in Greece. The term 'decentralised energy systems' has been used to describe state of the art technology that utilises renewable energy resources, domestic, industrial and agricultural waste. The proposal was approved in 1993 and financial support was granted by the Ministry for Industry, Energy and Technology. Key points of the project were:

- The monitoring of investments carried out in the sector of decentralised energy systems under specific incentives' status.
- The monitoring of currently valid legislative framework on an international level.
- The creation of a software package for the evaluation of the incentives valid in Greece over the last decades.
- The evaluation of the effectiveness of incentives valid in Greece over the last decades.
- The development and the evaluation of alternative incentives, as a final result of the project.

The project started in January 1994 and was completed in October 1995. Its scientific staff consisted of Professor D. P. Psoinos as scientific responsible, the other two authors of this paper as senior researchers, four graduated mechanical engineers as assistant researchers and seven graduating students of the Faculty of Mechanical Engineering of the A.U.T.

Decentralised energy systems can be classified according to many criteria and for the purpose of this project the energy resource utilised has been chosen. According to this the following classes resulted: Systems utilising domestic and industrial waste, systems utilising agricultural waste and by-products, systems utilising bio mass, small hydroelectric plants, wind energy systems, photovoltaic systems, geothermal systems, solar thermal systems.

For each of this systems class the basic function principles and possible uses have been recorded, as well as their applications implemented in Greece over the last 15 years, together with the incentives granted, where this has been the case. The data gathered during this task concerned: The location of the application, the date of the system's commission, the project carrier, the initial investment cost, the incentives' status valid at the time the investment was carried out and the main technical features of the system.

It has to be pointed out that gathering and processing these data was a strenuous task, since the applications have been carried out by various carriers, whilst a relative central data does not exist. The research team contacted the Public Power Corporation (P.P.C.), the Centre for Renewable Energy Sources (CRES), the Energy Directorate of the Ministry for Industry, Research and Technology, the Greek Telecommunications Organisation, the National Statistical Service, the Technical Chamber of Greece, Municipalities and Prefectures etc. The information collected has been verified by questioning the contractors of the projects, both Greek and international companies. Within the framework of this research project, 106 investments have been monitored. The overwhelming majority of 90 cases refers to small hydroelectric plants, wind generators, photovoltaics and solar thermal systems, which form the nucleus of renewable, decentralised energy systems in Greece.

In parallel with the research project concerning the investments carried out in Greece, another piece of research was undertaken on the legislative framework concerning decentralised energy systems in Greece and the E.U.

Particular interest has been paid to:

a) Greek legislation (Legislative Acts N. 1559/85, N. 2244/94) which defines

- the conditions under which allowance is given to private carriers for the production of electricity, and
- the incentives provided by the state to enhance private carriers to enter this market

b) Legislation, directives, decrees and recommendations issued by the E.U. (CEC DGXVII, 1993), concerning development programmes and measures.

c) The main characteristics of the national legislation of the E.U. member states (CRES, 1995).

2. Determination of Typical Decentralised Energy Systems and Production cost Assessment

After the data collection was carried out, they were evaluated in order to define the most applicable and viable systems, under the Greek climatic, hydrogeologic and financial conditions. The most appropriate systems one ought to consider proved to be small hydroelectric plants, wind generators, solar thermal systems and photovoltaics (PV).

1. The reasons for this choice are the experience acquired in Greece over the last twenty years, both on a research and on an application level, their satisfactory performance, the suitable Greek climatic and morphologic conditions and the currently available know-how (Ministry for Industry, Energy and Technology, 1992, D. P. Psoinos, 1995). Another reason for the selection of these systems is the fact that they cover the complete spectrum of possible users-investors: Small hydroelectric plants are a case for larger investors like the P.P.C. and local authorities. Wind generators clustered in wind farms are a case for the P.P.C. and the local authorities, whilst single units can be implemented by small and medium enterprises. Photovoltaics can be used by the final consumer as well as the P.P.C. and solar thermal systems are particularly suitable for the final user, in the domestic or the tertiary production sector. The definition of typical systems has been carried out with respect to international practice, as well as national conditions.

A typical small hydroelectric plant has an installed power of up to 10 MW. Since this is a wide range one can differentiate three subclasses: micro plants, with an installed power of up to 2 MW, mini plants, which vary between 2 and 6 MW and small plants, with an installed power between 6 and 10 MW. The main technical features of these plants are the limited extent of civil engineering work needed to construct them, as the location is chosen having this condition in mind, and the complete automation of their operation, by means of integrated control systems. A survey carried out by the P.P.C. in 1989 has determined the most feasible locations, which were in most cases sites with relative high altitude differences but limited water flow rates. Hence, the use of Kaplan or Buble turbines is recommended (P.P.C, 1988-1995).

As typical wind generator one can define a horizontal axis generator, with a rotor diameter between 15 and 30 m, variable blade step and an installed power of 50 to 300 KW. The operation of the system is fully automated and it is usually connected to the P.P.C. grid.

In the case of photovoltaic elements one has to examine two different typical cases: Small autonomous systems, which are not connected to the grid and therefore need accumulators. Their peak installed power is small, not exceeding 700 Wp, and they are used in isolated areas for byous, transmitters or remote households. Large PV systems are connected to the P.P.C. grid, do not feature accumulators and have an installed peak power between 20 and 100 kWp.

Solar thermal systems, as used in Greece, are well suitable for building services. Two main sub-groups can be defined: Active systems, which can be adapted to almost any kind of building and produce hot water or air and passive systems, which are integral parts of the buildings' shell and produce warm air. Typical active systems are the flat roof- and vacuum collectors while typical passive systems are the thermal storage wall and the attached greenhouse.

Cost functions have been developed, which allow a sufficient approximation of the production cost for all these typical decentralised energy systems. The cost factors included in the functions are presented in detail in Table 1, together with the units of measurement, their reference basis and the way to estimate them. The final form of the functions was APC = f(Cinit, E), where APC is the annual energy production cost, Cinit the initial investment cost and E the useful annual energy production.

The methodological approach used for the determination of the cost function relies on the norm developed by the European Wind Energy Association for the feasibility study of wind generators (EWEA, 1991). The specific cost factors presented in table 1 take into consideration both international literature data and the experience from Greek practice (A.M. Papadopoulos, 1994).

Particularly for the small hydroelectric plants and the wind generators the researchers have utilised technical and financial data of the P.P.C, which has been, together with local authorities, the only energy carrier active in Greece until now.

The experience, and hence the data available, on photovoltaics is very limited in Greece, as it has been confirmed by this survey. The projects carried out so far had a pilot or demonstration character and a respective high cost. Therefore, we used data from the European market and large PV producers (Tacke, NedWind, Bonus, BP Eurosolar, 1996).

In the sector of solar thermal systems, on the other hand, a large amount of data has been available, as Greece has a leading role over the last 20 years in the field of solar collectors and passive solar technology (M. Papadopoulos, 1991).

3. Development of Software for the Evaluation o Investments

As mentioned earlier, one of the aims of the research project has been the development of a computer programme for the evaluation of the effectiveness of the incentives valid in the energy sector in the past. The research team regarded as appropriate to develop a purpose-built, user friendly, computer programme that will fulfil this specification, being simultaneously the tool for the evolution of the proposed incentives scheme. The programme has been created in Visual Basic and operates under the MS-Windows® 3.1 environment. The required hardware is a 486 DX - PC, with at least 4 MB RAM.

A prime target of the new programme has been the evaluation of the effectiveness of an investment proposal both for the national economy and the private investor. This differentiation is inevitable as there are four basic factors that influence the results of the evaluation of a specific investment plan. The results can vary depending on the valuator's aspect, namely the national economy's aspect and the private investor's point of view. The influential factors are:

a) The reduction of indirect fiscal income for the national economy, due to the substitution of oil by renewable energy sources, i.e. in the case of domestic space heating by means of passive solar systems. It has to be underlined, that the taxation on oil is very high in Greece, laying at approximately 100% of the oil's import cost.

b) The reduction of foreign currency outflow for the national economy, when oil, or electricity produced in oil-fired plants, is being substituted. It has to be noted, that the main conventional energy sources used in Greece are indigenous lignit and imported oil. In the case of lignite substitution the currency outflow reduction is negligible. On the contrary, this reduction is highly significant in the case of direct use of oil, and of electricity produced in autonomous oil-fired power plants. Wind generators producing electricity in the Aegean islands are a typical example for the latter case.

c) The foreign currency outflow for the import of the equipment needed at the decentralised energy plants.

d) The benefit for the national economy, due to the large differences in the production cost of electricity: Lignite-fired power plants produce electricity in the Greek mainland at an average cost of 0.06 US+ / kWh. The respective cost at the autonomous oil-fired plants in the islands reaches values of 0.18 to 0.26 US+/kWh. The national P.P.C. sells power at the same tariffs all over Greece, and a typical average retail price for the household is currently 0.10 US+/kWh, it is evident that financial losses are considerable in those areas not connected to the national grid. In our example this would mean a loss of approximately 0.12 US+/kWh (P.P.C, 1993). Hence, as long as wind-generated power has a lower production cost than the conventional generated one, financial losses decrease and if the cost is lower than the average retail price, which is on the whole the case for wind generators, than it is beneficiary.

These four factors, although crucial for the macroeconomics feasibility of decentralised energy systems, do not affect the evaluation of the feasibility from the private investor's point of view. In this case it has to be examined under strict micro economical criteria.

As evaluation methods the Net Present Value (NPV), the Internal Rate of Return (IRR) and the Cost-Benefit Analysis (CBA) have been used (D. P. Psoi¬ nos, 1990, A. M. Papdopoulos, P. E. Georgiades, D. P. Psoinos, 1996). The results in the programme output are:

- The NPV and CBA index for the national economy
- The NPV and the IRR for the private investor, and
- The total cost of the produced kWh (LCOE).

The results are presented either in tabular or in 2- and 3-dimensional chart form. The input data required by the programme are distributed in five tables, which refer to:

1. The initial investment cost, which contains all investment features subject, to the Greek depreciation regulations.
2. The financing scheme. This contains the percentage of participation by the investor's own capital, the eventual subvention and the long term loans, with all the necessary data (o.e. interest and pay-back period).
3. The working capital. It contains the data on short-term loans with the respective terms.

4. The annual cash-flows. This table contains data on the investment's evaluation life cycle, the basic cost elements of production, operational and overhead expenses per annum, the useful annual energy production and the respective resell price, according to the electricity tariff regulation.
5. The additional data needed for the system's feasibility, which is divided into two sub-tables. The first contains all monetary and fiscal data needed, like capital cost, inflation and taxation rates. The second table contains all data needed for the evaluation of the investment from the national economy's aspect, which are:
   - the substituted energy source (i.e. oil, lignite or oil-produced electricity)
   - the reduction of foreign currency outflow, with respect to the substituted energy source
   - the foreign currency outflow, due to the import of equipment
   - the conventional electricity production cost
   - the pre-tax oil import cost
   - the pre-tax oil retail price
   - the pre-tax electricity production cost
   - the deflated annual energy price variation

4. Evaluation of the Incentives' Effectiveness in the past

The evaluation of the incentives valid over the last years in Greece showed that they were all in the form of subsidies granted for the initial investment. Almost exclusively these subsidies have been part of European Union programmes for the promotion of renewable energy sources or regional development, like the Thermie, Leader or Interreg. 36 of the 106 investments recorded have been examined in order to evaluate the incentives' effectiveness. Three of these investments were in small hydroelectric plants, twenty three were wind-generators and wind-farms, four were photovoltaics and six large scale solar thermal projects.

By using the developed software the investments' feasibility and viability has been analysed, both for the private investor and the national economy. The analysis was carried out both with and without the benefits provided by the incentives that have been actually valid for those specific investments. In each case these data have been verified by the investors, or the contractors or both. In the very few cases where this has not been possible, the input data have been estimated by using the cost analysis functions as defined in the typical systems description.

The results drawn were rather interesting, concerning the importance and the efficiency of the incentives:

- 1 out of 3 small hydroelectric plants, 8 out of the 23 wind-generators, 1 out of 4 photovoltaics systems and 2 out of 2 large scale solar thermal systems would not be feasible for the investor without the incentives. At the same time, however, and this was an important point, the investments remained feasible for the national economy, despite the monetary cost of the subsidies.
- 12 out of 23 wind-generators would have been feasible investments, evenwithout the incentives. The latter helped in making the investments more attractive.
- There were also cases, where the incentives did not help in turning the investments into profit. This was the case in 2 out of 3 small hydroelectric plants, 3 out of 4 photovoltaics systems and all 4 large scale solar thermal applications carried out in the Greek mainland. This conclusion applied only on 3 out 23 wind-generators.
- The effect for the national economy was in all cases positive, when the subsidies were granted by the E.U., with the exception of the photovoltaics systems, where in 3 out of 4 cases the investments were not feasible.

Without the incentives, the results remained practically unaltered for the national economy, though the financial performance was slightly less attractive.

5. Development of the Proposed Incentives

At the final phase of the project the research team proceeded to the development of an effective system of incentives, which has been the proposal presented to the General Secretariat for Research and Technology. The proposed system utilised the data collected and the conclusions drawn from all the previous phases of the project. The incentive's system includes:

- The incentives which will enable viable and profitable investments in the sector of decentralised energy systems, both for the private investor and the national economy, and
- The legislative and administrative interventions which have to be undertaken by the Geek state to promote effectively the decentralised energy systems.

Specifically, the development of the incentives was carried out in the following way:

At first two classes of incentives have been formed, aiming at the direct and indirect support of the investments. The first class includes the subsidy of the initial investment cost and the latter the subsidy of loan interest, enhanced amortisation rates, taxation allowances and subsidy of the produced energy, in terms of higher buy-back tariff rates.

After this stage these incentives have been evaluated and the most suitable have become the subject of further research. The evaluation and choice of the incentives was based on the following characteristics:

- Investments in decentralised energy systems are capital intense ones
- They have a very long life-cycle
- Operational and maintenance expense are low or negligible
- There is only one product
- This product is consumed either by the producer himself or it is being bought by the Greek state, via the P.P.C., at fixed tariffs.
- The useful annual energy production is small, compared to conventional energy systems.

Taking these characteristics into consideration, the research team has chosen as most suitable incentives the subsidy of the initial investment cost and that of the produced energy, in terms of higher buy-back tariff rates. The main rationale behind this choice is that the high initial investment cost, combined with the rather limited annual energy production, indicate that there is a good cause for direct support of the investment over the first years of its life-cycle, in form of an initial investment subsidy. Indirect incentives like the subsidy of loan interest, enhanced amortisation rates and taxation allowances were found to be effective. The limited annual cash inflows, particularly over the first years, do not allow utilisation of such incentives. On the contrary, the subsidy of the produced energy, in terms of higher buy-back tariff rates, has been found to be a very effective indirect incentive scheme, for the following main reasons:

- It connects the investment's support with its productivity, driving the private energy producers towards a more intensive use of the invested equipment and capital.
- As an incentive it is objective and fair, since the monitoring of the produced energy can be carried out in a way excluding overpricing or defraud.

The above mentioned alternative incentives have been studied for each one of the four decentralised energy systems, in order to determine the extent of subsidies affordable by the Greek state that will make the investments feasible for the national economy and attractive opportunities for private enterpre¬neurs. The methodology used for the determination of the incentive's impact on the financial results of the investment has been studied for each typical decentralised energy system. There are three possible scenaria for he interconnection between private investor and national economy, that effect the extent of incentives:

a) Positive financial results both for he national economy and the private investor

b) Negative financial results both for the national economy and the private investor

c) Positive financial results for the national economy but negative for the private investor.

In case (a) possible incentives are not recommended, as they will reduce the positive results for the national economy, only to further improve the investor's profits.

In case (b) possible incentives might turn an undeasible investment into profitable for the investor, burdening the already negative results for the national economy. Hence, it is unwise to recommend incentives in this case, although this was a policy frequently occurring in the '80's.

Case (c), however, is an almost ideal case for the implementation of an incentives' policy. In this case a margin for providing incentives exists. One can determine the extent of the possible incentives, both in form of the subsidy granted and of a higher buy-back rate. This is being achieved by recalculating the feasibility of the investment for a theoretical initial cost, which consists of the actual one added to the subvention granted to the investor. In this way, the critical initial cost is being determined, for which the investment becomes feasible for the investor, but remains also feasible for the national economy.

This conclusion is hence valid in both directions as the subsidise granted by the state will be covered from the expected annual savings and on the other hand the initial investment cost carried by the private investor will be reduced to a value lower than the critical one. The following example of a micro hydroelectric plant will shed more light to the procedure.

Summarising, the final incentives' system for the promotion of decentralised energy systems in Greece, with respect to the resource utilised, as it has been proposed to the Ministry of Industry, Energy and Technology is presented in Table 2.

6. An illustrative example

As it has already been mentioned in Par. 4, small hydroelectric plants can be divided into three subcategories, with respect to their installed power. The main parameter influencing the feasibility of a small hydroelectric plant is the initial investment cost. A survey in the field of turbo-machinery equipment, automation and control systems, led to determination of a range for the initial system cost values that is shown in Table 3. The micro plants present, for reasons of economy of scale, the highest specific cost, although high cost figures can under circumstances occur in mini and small plants also.

The annual useful energy production, the electricity buy-back rates, the amortisation rate and other data influencing the feasibility of the investment, are presented in the Table 4. All methods mentioned earlier have been applied to determine the investment's feasibility, with respect to the initial cost of the system, which has been proven to be the most significant parameter of the analysis. In Table 5 are presented the results of the method's application for the average minimum and average maximum initial cost.

In addition to the results of the feasibility analysis, we have determined the annual achievable savings, for the national economy, a figure fairly interesting with respect to the overall effect of the promotion of hydroelectric plants on the national economy level. It is important to be aware of these expected savings, as they determine the margins for the incentives that might be provided to the private investors, if necessary.

The analysis showed a fairly wide range of results, which was expected due to the variation of the initial cost of the investment. However, out of the three categories, the micro plants are the most interesting and have hence been chosen for the case of this example, for three main reasons:

a) the hydro-logical and geological potential for the implementation of micro plants is large and remains mostly unexploited.

b) although the specific initial cost is the highest, the total cost is fairly low, due to the small size of the plants, allowing hence the realisation of investments by small private enterprises.

c) due to the high initial cost the necessity for effective incentives is frequent, while this is normally not the case in mini and small plants.

The feasibility study showed, that for a specific initial cost exceeding 1.850 US+/kW the investment is not feasible, leading to a necessity for investments, either in the form of grant on the initial investment, or of higher buy-back rates. Therefore, a sensitivity analysis was carried out, for micro hydroelectric plants with an initial cost varying from 1.900 to 2.300 US+/kW. The analysis was carried out by calculating all the feasibility indices for an increasing cost, at a step of 50 US+. In Figure 1 are present, for reasons of simplicity with a step of 100 US+, the results for he Cost Benefit Analysis from the national economy's aspect and the Internal Rate of Return Rate for the private investor, with respect to the possible grant on the investment.

The presented data demonstrate, that for an initial cost o 1.900 US+/kW (scenario a) a grant of 2% would be necessary to make the investment feasible for the private investor. At the same time, a grant of up to 12% could be given by the state and the investment would still be beneficiary for he national economy. A grant higher than 2% and lower than 12%, would make the investment more attractive. On the other end of the cost range, for an initial cost of 2.300 US+/kW (scenario e), the grant needed for the private investor would be 12% at least, whilst the state cannot afford to give more than 4%, hence there is no possibility for providing an effective incentive.

The influence of the incentive's extent to the investment's feasibility becomes more obvious in a detailed analysis for one initial cost figure, which is presented in Figure 2, in the case for a plant with an initial cost of 1.950 US+/kW: Setting as a minimum acceptable IRR value 4%, and maximum CBA-index 1, it has been calculated that the maximum allowable grant would be 11,2%, ensuring an IRR value of 5,05%. The minimum necessary grant would be 5,4% ensuring an IRR value of 4,01%. Hence, it is up to the state to decide for a grant on the initial investment between these two values, 5,4% and 11,2%, providing an effective and feasible incentive.

The same approach was used to determine a buy-back rate, higher than the actual foreseen which is 80% of the electricity retail price, as mentioned earlier. The results of this analysis can be seen in Figure 3.

It can be observed, that the currently valid 80% rate is on the limit of acceptance, being hence unattractive. On the other hand, the buy-back rate could be increased up to 86%, being still acceptable for the national economy, and allowing a far better yield for the private investor, who would achieve an IRR value of 4,85%. hence, there is a margin between 80% and 86% of the retail price, in which lies a substantial incentive's potential for the production of electricity in micro hydroelectric plants.

In parallel to the financial incentives a series of legislative and administrative interventions have to be undertaken by the Greek state, in order to eliminate difficulties that have occured in the promotion of decentralised energy system. These difficulties result from the fact that some parts of the legislative framework are fairly old, dating back to the '50's, imposing bureaucratical and technical obstacles to the issue of permissions for such investments, that lead to delays. Furthermore, the lack of a central institution that will provide climatic, geological and technical data, as well as information on existing decentralised energy plants is a serious problem, as the authors have experienced it during this project.

7. Conclusions

The project has been completed in the autumn of 1995, by the time when the reviewed legislation on energy production became active.

Resuming, the authors believe that the results and the deliverables of the project can be a useful tool for the implementation of a sound and viable energy policy. In accordance to the E.U. decisions, Greece has set a medium term goal of doubling the contribution of renewable energy sources to the national energy balance by the year 2005. At present, this contribution lies at 1,9%. If this aim to be achieved in a financially reasonable way, one cannot avoid the adoption of a feasible incentives' scheme. The present legislation sets a good base for the development o decentralised energy systems. However, there is a significant margin for more effective incentives, particularly with respect to the produced actually energy.

Finally, there is still significant potential for further research, mainly in the interactions between the various incentives schemes, which are subjects of non-going and future research activity.

TABLE 1
Cost factors of typical decentralised energy systems

Cost factors	Small Hydroelectric plants	Wind generators	Photovoltaics	Solar thermal systems	
				Active	Passive
Equipment / construction cost [US$/kW or US$/m^2]	1,000 - 1,500	500-600	5,000-8,000	360	100-120
Installation cost [kWh/kW or kWh/m^2]	200-400	50	300-500	30	0
Grid connection & controls cost [kWh/kW or kWh/m^2]	100-200	15	300-400	0	0
Useful lifetime [yrs]	30 (machinery) 50 (dam)	20	15 - 20	15	50
Avg. annual operation time [hrs]	2,000	2,000			
Useful annual energy yield [kWh/kW or kWh/m^2]		2.200	800-1.200	400-600	80-120
Annual operational expenses [% initial cost]	1%	1%	0.5%	0	0
Annual maintenance cost [% initial cost]	1-2%	2%	0.5-2.0%	1%	0.5%

TABLE 3
Initial cost figures for hydroelectric plants

Plant size	Average minimum cost [US$/kW]	Average maximum cost [US$/kW]
Micro hyrdoelectric plants	1.900	2.400
Mini hyrdoelectric plants	1.500	2.000
Small hyrdoelectric plants	1.200	1.900

TABLE 2

Proposed scheme of incentives and regulations for the promotion of decentralised energy systems

Incentive \ Energy System		Small Hydroelectric Plants			Wind Generators	Photo voltaics		Solar thermal systems	
		Micro	**Mini**	**Small**		**Interconnected Systems**	**Autonomous Systems**	**Active**	**Passive**
Grant on the initial investment	Minimum	Not necessary *	Not necessary *	Not necessary	Not necessary	91% **	100% **	25%	20%
	Maximum	12%	Not necessary *			**	**	40%	30%
Subsidy on the buy back rate	Minimum	Not necessary *	Not necessary *	Not necessary	Not necessary				
	Maximum	63%	Not necessary *						
Improvement of the legislative framework		Long term contracts with the P.P.C. with specific buy-back rates for the produced energy			Simplification of the procedure for granting operation allowances				Revision of the General Buildings' Regulations valid currently
Support of the technological infrastructure					*Detailed map of wind potential and suitable locations on a national level*	*Development of business plans directly with interested parties & users like the P.P.C., the Telecommunications Organisation, the Naval Service for Lighthouses e.t.c.*		*Obligatory quality assurance and control of collectors according to ISO and DIN*	*Promotion by housing organisations and big constructors*

Remarks:

* : *A subsidy is not required for mini hydroelectric plants. However, the minimum subsidy could be granted, in order to make the investment more attractive*

** : A subsidy for photovoltaics is not feasible for the national economy. It can only be recommended for specific applications, like transmitters and remote light houses

(dark shading) : Measures are not feasible

(light shading) : Measures are not necessary

TABLE 4

Main parameters used for the feasibility study

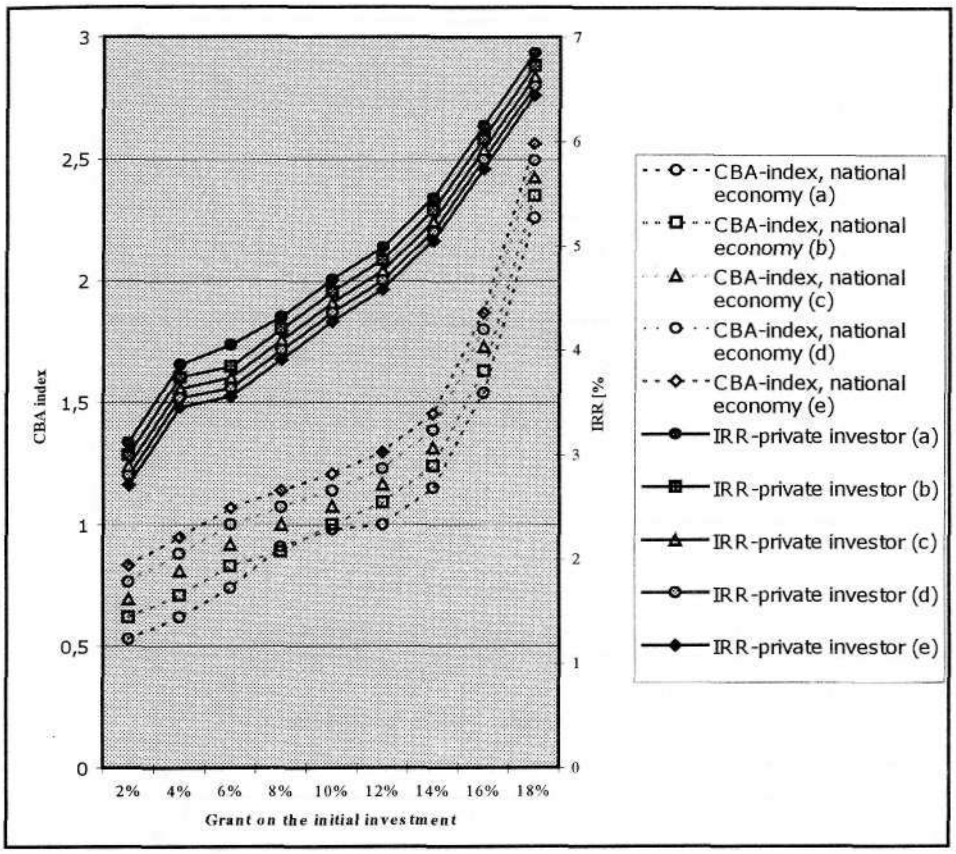
Symbol	Parameter	Units	Min.Value	Max.Value
Cains	Initial system cost	US$/kW	1,200	2,400
Lt	Useful life time of the mechanical equipment	years	20	30
Kx1	Value of imported equipment of the initial investment	%	30	40
a	Annual equipment depreciation rate	%	8	8
Qdes*F	Annual useful production	kWh/kW	2,500	4,000
Cpe	Electricity retail price (before taxes)	US$/kWh	0.09	0.11
te	Tax rate on the retail price	%	18	18
Cpel	Conventional plant production cost	US$/kWh	0.052	0.066
Pel	Electricity buy back price	US$/kWh	0.064	0.0884

Note: 1 US$ = 250 Greek Drachmae [GDrh]

TABLE 5

Results of the feasibility analysis

Feasibility Study	Units	Favourable	Unfavourable
Initial system cost	US$/kW	1,200	2,400
Levelized Energy Production Cost	US$ / kWh	0.0276	0.0552
Net Present Value for the private investor	US$/kW	913	-181
Internal Rate of Return for the private investor	%	7.61	2.49
CBA - Index for the national economy	-	0.52	2.52
Annual achievable savings for the national economy	US$/kW	57.6	0



Scenaria	Initial Investment Cost [US$/kW]	Scenaria	Initial Investment Cost [US$/kW]	Scenaria	Initial Investment Cost [US$/kW]
(a)	1.900	(c)	2.100	(e)	2.300
(b)	2.000	(d)	2.200		

Figure 1. Feasibility of micto-hydroelectric plants from the private investor's and the national economy's aspect, with respect to their initial cost and the possible grant

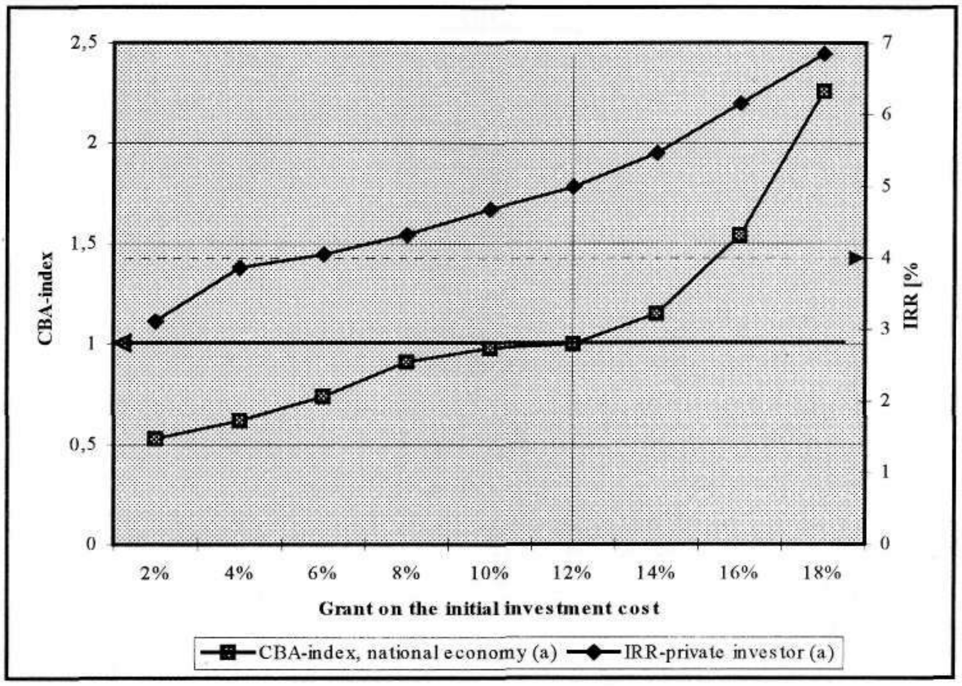


Figure 2. Feasibility of micro-hydroelectric plant, with an initial cost of 1.950 US+/kW, with respect to the grant on the initial investment

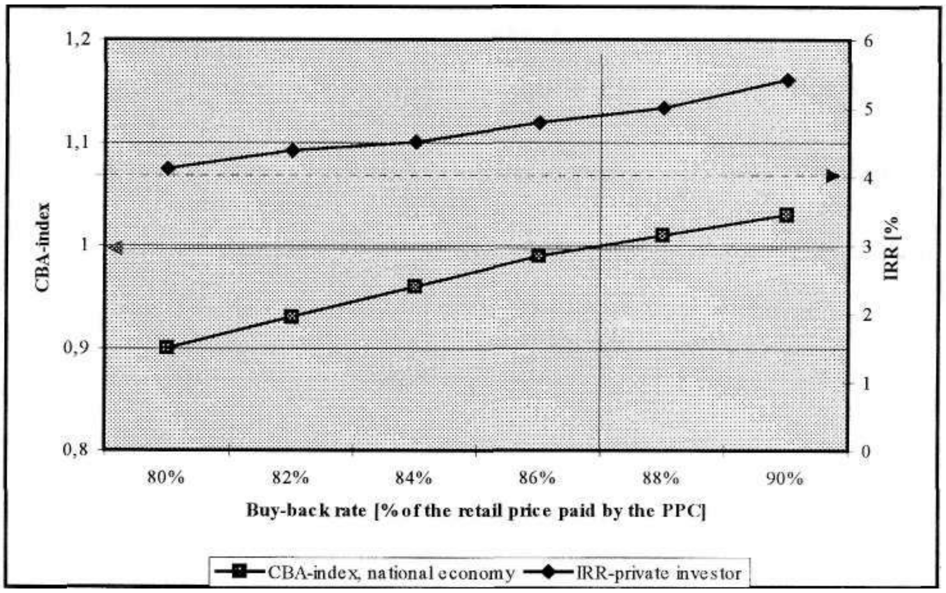


Figure 3. Feasibility of micro-hydroelectric plant, with an initial cost of 1.950 US+/kQ, with respect to the buy-back rate

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