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CAPITAL REQUIREMENTS FOR WATER HEATING: SOLAR VERSUS CONVENTIONAL EQUIPMENT

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CONTENTS

1. INTRODUCTION

When posing the problem of the mass introduction of solar water heaters, one of the main objections often raised refers to the additional capital costs this type of installation requires compared to conventional equipment.

This additional capital cost arises from the fact that the solar water heater does not provide 100% of the caloric requirements and therefore a conventional complement must exist simultaneously.

Since in LDC's it is often declared that capital is the scarcest of all resources it would appear that a serious problem exists for achieving penetration of the water heaters.

We hold this approach to be totally mistaken because, when considering the capital requirements of both alternatives, conventional and solar, only the capital costs of the dwelling unit are taken into account and not the combined investment which must be made in the economic system so that both types function.

2. TOTAL CAPITAL REQUIREMENTS

The installation of a solar water heater, once the initial investment at user level has been made, does not require further investments to be made

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in the rest of the economic system, either simultaneously or during the useful life of the equipment, since the energy source is the sun.

Contrariwise, all conventional systems for heating water require additional investments in the rest of the economic system, either prior to or simultaneously with the user's investment and thereafter permanently during the useful life of the installation.

Whatever the energy source which supplies the conventional system - liquefied gas, natural gas or electricity - important investments in different sectors of the economy must be made, according to the case in question, before the energy reaches the end user.

If the energy source is electricity, a distribution and transmission network from the power station to the user must be constructed, an electric power station must be erected and it is also necessary to make other investments to supply fuel to the power station if it is thermal electric.

These investments refer to the system of marketing fuels, their transformation, transport, production, search or exploration, since they are all non-renewable sources.

If the source is natural gas, it will also be necessary to make the corresponding network, the transport system, the storage facilities, and the necessary investments for exploitation and production of the gas.

Finally, if we consider liquefied gas, it will be necessary to set up the distribution network, the refinery or extraction plant, transport facilities and investments for producing and exploring for oil or natural gas, according to its origin.

Evidently the foregoing assumes that the economic system under consideration is in condition to produce fron its own resources all or some of the energy sources mentioned above.

A different problem arises if the country does not have the corresponding energy sources and must import them, in which case it will not be necessary to make some of the investments mentioned. However, a permanent flow of foreign currency will be generated during the useful life of the conventional equipment and this requires another type of analysis which we shall make later.

Having posed the conceptual terms of the problem, we shall pass on to develop some concrete estimates of what amounts of investment are required to supply conventional water heating equipment, in addition to those investments made by the user.

These investments are evidently different according to the type of energy used and even for the same energy type they differ widely, in particular those related to the fuels oil and natural gas, due to the different characteristics of the resources belonging to each country.

We shall put forward three possible conventional systems:

- With oil derivatives (either liquefied gas for individual installations or some intermediate derivative for multiple installations).
- With natural gas (both for individual and multiple installations).
- With electricity (for individual installations).

In all cases we shall use investment coefficients estimated on the basis of concrete development programs carried out or projected in different Latin American countries.

2.1 COMPARISON WITH A CONVENTIONAL SYSTEM USING OIL DERIVATIVES

If we wish to compare a solar energy water heating system complemented by oil derivatives, with an exclusively conventional system, the additional investment the user must make for the solar system must be analyzed and compared with the marginal investment the economic system must make in the case of using conventional equipment.

2.1.1. Additional Investment Necessary for the Solar System.

As the basis for the estimate, commercial data corresponding to equipment on sale in Argentina in mid-1977 will be taken, for two different sizes.[1/]

Adding the costs of installation and accessories, which are estimated at about 20%, and taking into account the effect of mass production economies we shall use a figure of 135 dollars (1977) for the small size and 270 dollars for the large, for the period 1980-85.

Both values are equivalent to a cost of 77 dollars/m^2 which is coherent with data obtained from other bibliographic sources.[2,3,4,5/]

The choice of size of the equipment was made in function of the number of persons per dwelling which exist in the most and least favourable zones of Latin America. For the first case the high part of Colombia, Ecuador, Venezuela, a solar water heater for a group of 6.7 persons per user would enable a saving of 0.225 t.o.e./user/year of useful energy.

For the second one, the temperate zone of Argentina and Uruguay, a solar water heater for 3.1 persons per user permits a saving of 0.10 t.o.e./user/year of useful energy.

1/ - Retail price list of "Termosol", August 15, 1977. Data in pesos. Exchange rate 440 pesos/US dollar.

2/ - Energy for Rural Development, National Academy of Sciences, Washington D.C. page 66. "The cost of solar water heaters varies considerably with the quality of construction, but in general the better metal/glass collector units with insulated storage tanks involve a price for the collector of about 10-12 dol.per ft^2 (100 dol per m^2) in USA. For a typical family-sized installation of 30 ft^2 (3 m^2) and 50 gal (200 lt) storage, a total installed cost of about 300 dol can be assumed.

3/ - Copper Development Association Inc. Technical Report, How to design and concrete oil development plans in various countries of the region in order to obtain more realistic, complete values.

It proved possible to obtain global information on Argentina and Mexico, and partial data on Colombia and Perú.

The results obtained are detailed in Table N° 1 by stage of the production process in all the possible cases.

As can be seen, there is a wide variety of values which correspond to the different productivity of the oilfields and to the different patterns of the Refining, Transport and Distribution system but in all instances, they are higher than the data previously mentioned (except in the case of Mexico).

Since the data are given in dollars of different years and some of the values have been estimated, due to lack of information, we can adopt for the calculations a value of 700 1976-dollars/t.o.e. for Argentina, 500 1976-dollars/t.o.e. for Peru and Colombia and 200 1976-dollars/t.o.e. for Mexico.

D.C., November 1976. Quoted in: Denis Hayes, Ibid.

6/ - Gordian Associates Ind. LDC Energy Supply/Demand Balances and Financing Requirements. Washington D.C., Feb. 27, 1978. In Chapter 3 and Exhibit C the following values are given:

- Capital requirements for Oil Exploration, Development and Transport for non-OPEC members.

  Mexico 5, 300 dollars/B/day - 107 1976-dollars/t.o.e./year
  South America 3,800 1976-dollars/B/day = 76 1976-dollars/t.o.e/year.

- Capital requirements for refining

  Atmospheric Distill. 1600-3000 1976-dollars/B/day = 32-60 1976 dollars/t.o.e./year.
  Hydroskimming 1000-2200 1976-dollars/B/day = 20-44 1976-dollars/t.o.e./year.

TABLE N° 1

UNIT INVESTMENT COEFFICIENTS – OIL INDUSTRY
(Dollars/t.o.e./year)

	Argentina		Colombia	Perú		Mexico
	(1)	(2)	(3)	(4)	(5)	(6)
Exploration, Development & Production	360	375	256	155	-	95
Transport	120	230	-	-	360	40
Refining	120	90	-	-	-	60
Marketing	110	65	-	-	115	-
Others	-	-	-	-	-	5
TOTAL	710	760	-	-	475	200

(1) - National Energy Plan 1977-1985.

(2) - 9th Energy Economics Course Planning Exercise (1977-1992).

(3) - Plan to drill 730 wells in 10 years. The coefficient without including replacement of the decline gives 167 dollars/t.o.e./ year. A 7% decline was estimated in accordance with historical values.

(4) - Real investments in 1971-76 for exploration and development, do not include production. Estimated on the basis of production capacity in function of identified reserves, does not include investments to compensate decline.

(5) - Two-year plans 1975-76, 1977-78. Although the forecast investments were made, the production goals for 1976 were not accomplished, therefore the real coefficient would be much higher.

(6) - Six-year plan 1977-82. Petróleo Internacional, June 1977.

To be able to define the amount of investment corresponding to energy saved by the solar water heater, it is necessary to define the total fuel volume which must be supplied to obtain an equivalent service.

On going from useful energy to net energy, a yield of 0.5 will be used, i.e. the consumption of useful energy must be multiplied by two.

To go from net energy (at user level) to gross or primary energy, consideration must be given to different losses and consumptions which occur throughout the handling of the oil and its derivatives, from the user to the oilfield.

It can be estimated that between the user and the refinery gate, consumptions and losses equivalent to 15% occur (distribution losses and consumptions, refining losses and consumptions) and that crude oil transport and production account for an additional 10% (transport losses and consumptions, production losses and consumptions).

To summarize, the consumption of useful energy at user level must be multiplied by 2.53 (2 x 1.15 x 1.10) to obtain the corresponding primary energy.

For the most favorable zone and using the investment coefficient for Colombia the investment which the economic system would have to make to supply conventional equipment equivalent to the solar water heater would be 285 dollars. This value is about 6% higher than that required by the solar system in this zone.

For the other zone and using the investment coefficient for Argentina, the additional investment of the conventional system is 177 dollars. This value is about 31% higher than that of the solar system. Finally in the case of Mexico, the necessary investment connected with the conventional system would be 93 dollars. In this area a solar water heater of medium size would be necessary with a yield of 0.185 t.o.e./user/year for an average of 5.5 person per user.

The additional investment cost would be 235 dollars. This means that the conventional systems require in this case only 40% of the investment necessary for the solar system.

Here, however, it is necessary to take into account that the installation of a solar water heater does not in reality mean a reduction in oil investment but instead it frees the corresponding amount of energy for exportation and therefore the benefit for the country is represented by the present value of the income obtained during 15 years (estimated useful life of the equipment) for exportation.

If an export value in constant currency of 90 dollars/t.o.e.*/ and an actualization rate of 10% per annum are taken, the corresponding present value is 684 dollars/t.o.e. which, multiplied by the saving in primary energy due to the solar heater (0.465 t.o.e./year) gives a value of 318 dollars, 35% higher than the investment necessary to install the solar water heaters, or in other words, the investment is recovered in 8-1/2 years by means of the additional export of oil saved by the solar water heater.

Before concluding this point, it could be mentioned that in analyzing the cost of the conventional alternative for the economic system, no allowance was made to compensate the system in question to the exhaustion of a non-renewable resource such as oil.

Nor is it certain that the investment coefficients include the interests during construction which in the different stages of the oil industry occur due to the maturity period of more than one year which is the case in most investments.

Conversely, the solar systems, due to their very characteristics, do not require to carry these interests and their benefits begin to be obtained very soon after the investment.

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* - At the 1981 prices of crude, the present value in constant currency would be approximately twice as much and therefore the period of repayment would be reduced to about 4 years.

2.2. Comparison with a natural-gas-based conventional system.

In this case a solar system using natural gas as complementary fuel will be compared with a conventional system using only natural gas.

2.2.1. Additional investment for the solar system

The additional investment made by the user to install the solar water heater is the same as that established in point 3.1., and this value will be used directly.

2.2.2. Additional investment for the conventional system

In relation to the additional investment which must be made in the system in the event of resorting to the conventional system, the situation is different from the case of oil derivatives and similar to that of electricity as will be seen later.

Since the solar water heater does not supply 100% of the requirements and the conventional complementary system must be in condition to assume 100% of the load during certain periods, there are certain investments for the conventional system which will have to be made in any case.

To begin to analyze the system from the user to the resource, the following assumptions were made:

a) Distribution network. The investment is similar for both systems since the network must be in condition to supply all the loss at specific moments, which it is expected will coincide with the maximum demand of other uses and users.

b) Storage or peak shaving systems. Since the additional requirement of natural gas in the case of the existence of solar water heaters will be during short periods of time, it is assumed that this additional demand will be supplied by storage plants (either natural, gaseous or liquefied gas) or by peak shaving equipment (Propane/air/or LNG Plants).

Therefore, the investment under this heading will increase for the case of the combined solar/natural gas system.

c) Transport system. On the basis of the contents of the preceding paragraph, it is considered unnecessary to expand transport capacity in the solar system, but necessary in the case of the conventional system.

d) Exploration, development and production. As we are considering the surplus natural gas consumption in the conventional system compared to the solar system, the investments necessary for covering the surplus must be charged totally to the conventional system and not to the solar system.

The investment coefficients corresponding to each heading will now be analyzed.

Unfortunately the information available as regards natural gas is more limited than in the case of oil.

On the one hand we have the data of bibliography already referred to[7/] and on the other, data referring to the Argentine case of the sources mentioned previously.

In accordance with the above, the additional investment of the conventional system will be given by the sum of the values corresponding to Exploration, Development and Production, Transport and other and reduced in the additional Storage investment.

In the same way as for oil derivatives, it is necessary to allow for the losses and consumptions of natural gas distribution, transport and production

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7/ - Gordian Assoc. Inc. Ibid. Natural Gas Capital requirements.

in order to estimate the equivalent requirement in primary energy of the solar water heater. It is assumed that this value reaches 20% and that the yield of a natural gas hot water tank is 0.65.

TABLE N° 2

UNIT COEFFICIENTS OF INVESTMENT: THE GAS INDUSTRY
(Dollars/t.o.e./year)

	Argentina (1)	Argentina (2)	Mexico (3)
Exploration, Development & Production	30*/	405	65
Transport	235	118	50
Storage	25	10	-
Distribution	120	250	-
Others	10	42	-
TOTAL	420	825	-

(1) - National Plan Energy (1977-1985)

(2) - Planning Exercise, 9th Energy Economics Course (1977-92).

(3) - Gordian Assoc. Inc.

*/ - Only investments for harnessing and treating are considered. Exploration, Development and Production investments not included.

Multiplying the values of primary energy equivalents by the respective investment coefficients, the following values of investment required for the conventional system are obtained: First zone, 168 dollars, second zone, 100 dollars and 48 dollars in the third one.

If these values are compared with the additional investment which the user must make in the solar system (see point 3) it will be seen that they only represent 20, 62 and 75% respectively of the solar equipment investment.

In other words, in the particular circumstances of natural gas being available, the conventional alternative is less capital intensive than the solar alternative.

This is largely due to the fact that when using natural gas as the complement to the solar heater the corresponding distribution network must be constructed in any case and, in the particular case of Mexico, to the low investment coefficients per additional unit of natural gas required.

Nevertheless, it must be observed that out of the whole region, only Argentina has developed an extensive distribution network covering a very high percentage of the urban population. In Colombia, Mexico and Venezuela the networks are very much smaller and in the remaining countries they are practically non-existant.

Therefore in those countries, liquefied gas or oil derivatives could be used as the complementary fuel and the gas in the industrial sector to substitute the oil derivatives.

To the extent that countries with natural gas supplies develop their resources and orient them towards urban type consumption, this will act as a brake on the penetration of solar energy in that area.

However, it is important to note that in the country where the situation would apparently be most unfavourable, Mexico, it is there that, according to the capacities study, a market has been developing for several years now for the installation of solar water heaters without any kind of official support and in competition with the subsidized prices of conventional fuels.

2.3. Comparison with a conventional system supplied with thermal electric energy

In this case the comparison will be made between a solar system which uses electricity as a complementary energy source and a conventional system using electricity exclusively.

The comparison will be made in relation to a thermal electric conventional system since, if hydroelectricity exists, we have a case of competition between renewable energy sources and because hydroelectric investment is very variable according to each particular case thus requiring a specific study for each one.

As regards nuclear energy, its development in the region in the period under analysis is limited to very few countries and even within them, to certain regions or specific systems.

2.3.1. Additional investment in the solar system

As indicated for the case of natural gas, it is considered to be similar to the estimate in part 3 for oil derivatives.

2.3.2. Additional investment in the conventional system.

As occurs with natural gas, there are certain parts of the conventional system which must be developed at all events, in order to be in condition to supply 100% of the load when the solar system does not do so.

Moreover, it is more difficult to obtain global investment coefficients for a purely thermal electric system since the existing plans are always combinations of thermal and hydraulic systems.

Furthermore, the different characteristic of electricity demand, in quantity and permanence, for the conventional system and the combined one, (solar-electric), means considering a different type of construction program in each case.

Therefore two alternatives systems have been assumed and their respective capital costs will be calculated in order to obtain the corresponding difference. Going from the user to the resource, the following is the situation:

a) Distribution and transport system: It will be assumed that they are similar in both systems and therefore there will be no difference in their capital requirements.

b) Generation system: For the case of the solar-electric system it will be assumed that suitable size gas turbines will be installed since the electricity requirement has specific "peak" demand characteristics.

c) Fuel supply: In order to simplify the calculations, it will be assumed that in both cases oil derivatives will be used as fuel although taking into account the different specific consumptions of each equipment assumed, as indicated in the preceding paragraph.

In order to determine capital requirements which will ensure the supply of the fuel, the coefficients already calculated in part 3.1.2 will be used.

In relation to the capital cost of the power plants, this is variable in function of size. The difference between the two types of fitting out are also variable.[8/]

8/ - Capital cost dollars/Kw.

Power MW	Steam Power Plant	Gas Turbine	Difference
10	1410	480	930
15	1320	400	920
30	1090	320	770
50	850	270	480
100	690	210	480
200 */	500	170	330

*/ - Data from Gordian Assoc. Inc., Ibid., Exhibit 3.3.

Taking into account that except in a few countries the systems in Latin America are not on a very large scale, a value of 400 dollars/Kw will be taken as the difference between a steam and a gas turbine power station.

For the former, a fuel consumption of 0.28 k.o.e./Kwh can be assumed and for the latter, 0.42 k.o.e./Kwh, values which are similar to the average consumptions recorded in the region.

According to the technical name-plate of the solar equipment being taken as the basis for the analysis, the small size is fitted with a 1.5 Kw resistance and the larger with one of 2 Kw.

The total caloric requirements to be supplied in each zone are 0.30, 0.13 and 0.23 t.o.e./user/year in useful energy assuming that the solar supply represents 75% of the total in the first and second zones and 80% in the third.

Estimating an 85% yield for the electrical supply, an equivalent of 0.08 t.o.e./Mwh and 18% of distribution losses and self-consumption in power stations, we get a total consumption of 5,200, 2,250 and 3,980 Kwh for the conventional electric system. For the combined solar-electric system the values are 1,300, 515 and 780 Kwh.

If we estimated the consumption surplus of the conventional systems over the solar one we obtain a value of 0.91, 0.41 and 0.79 t.o.e./year in each zone.

As we indicated in point 3.1.2 these fuels used at electric power station level should be affected by coefficients which take into account losses and consumptions of distribution, processing, transport and production, in order to reach the primary energy level.

It was assumed that they are about 10% up to the refinery gate (distribution and processing losses and consumption) and an additional 10% up to the oilfield level (transport and production losses and consumptions).

Therefore the difference of oil to be supplied in both systems will be 1.10, 0.50 and 0.95 t.o.e./year.

Finally, consideration must be given to the installed power in the power plant necessary for supplying both systems. Due to distribution losses and self-consumption, it will be 18% higher than the installed power at the user level, i.e. 177 Kw for the small equipment (second zone) and 2.36 Kw for the large equipment (first and third zone) for each case analyzed, and we get a figure of 1,494, 1,058 and 1,134 dollars which in comparison with the corresponding solar system investment is 5.53, 7.83 and 4.83 times greater.

In this case it will be seen that the conventional system is several times more intensive in capital requirements than the solar solution, since with the total investments the economic system must make in the case of the conventional electric system it is possible to cover the installation of between 4.8 and 7.8 solar water heaters according to the cases analyzed.

Over and above any opinions about the exactitude of the coefficients used in this calculation, it is evident that in the case of the conventional electric system the additional capital requirements are substantially higher than those of the solar system.

This is due to the high transformation losses in electrical energy associated with this alternative and to the investment requirement at power plant level with very low utilization factors.

3. COMPARATIVE ANALYSIS FOR OIL-IMPORTING COUNTRIES

3.1. Introduction

Obviously the analysis carried out in the foregoing is not valid for many countries of the region as they have no possibility of producing internally the additional fuel requirements which a conventional system could generate compared with the solar system and therefore their only alternative is importation.

Generally speaking, all the countries of the region which lack resources of their own resort to importation of crude which is processed within these countries. Only marginally are derivatives imported, except in the case of liquefied oil gas which is imported in significant quantities into almost all the countries of the region.

Although there are small differences in the import prices of crude and liquefied gas due to differences in quality in the first instance and freights according to origin in both cases, they do not justify an independent analysis in this type of estimate.

Therefore, two generic cases applied to all the regions will be analyzed:*/

a) Importation of crude at a CIF price of 100 dollars/t.o.e.
b) Importation of liquefied gas at a CIF price of 150 dollars/t.o.e.

3.2. Importation of crude

It is evident that by resorting to the importation of fuels it is possible to avoid partially the additional capital requirements of the conventional systems, but the country becomes subject to an additional outflow of foreign currency during the entire useful life of the solar system considered.

From an economic point of view this can be taken into account calculating the present value of this currency flow.

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*/ - In 1981 the import prices in 1978 dollars are at least twice these values.

From the financial viewpoint it is necessary to remember that the payment of oil imports must be made in cash or at very short term, while a program of capital investments can always be financed over the medium or long term, amortization of the loan and its interests being covered by the saving in imports.

If a useful life of 15 years is assumed for the solar equipment and an actualization rate of 10% per annum (higher than the present interest rates on currency in the international market), the respective updating coefficient is 7.6.

Therefore, importation during 15 years of 1 t.o.e./year at 100 dollars/t.o.e. represents a present value of 760 dollars/t.o.e.

This value will be applicable to the conventional systems based on oil derivatives (multiple systems) or those based on thermal electric energy.

3.2.1. Systems based on oil derivatives

As distinct from the analysis made in point 3.1 only investments in refining and marketing (perhaps partially transport) have to be considered in this case, to which the present value of imported crude must be added.

Table N° 3 gives details of the situation for each of the regions analyzed.

It can be seen that in these conditions the value of the investments plus the present value of the imports, exceeds the capital requirements of the solar system by between 53% and 70%.

To express this differently, it could be said that the additional investment of the solar system over the conventional is equivalent to the present value of 5.9, 7.0 and 6.4 years of importation for the first, second and third

TABLE N° 3

CAPITAL REQUIREMENTS AND PRESENT VALUE OF IMPORTATIONS
(System with oil derivatives)

	1st.Zone	2nd.Zone	3rd.Zone
Present Value Imports dollar/t.o.e. (1)	760	760	760
Additional investments Refining, transport, marketing dollar/t.o.e. (2)	140	140	140
Additional importation for solar equipment installed (3) t.o.e./year	0.51	0.28	0.42
Investments + Present value (1) + (2) x (3) = 4 dollars	390 460 70	175 207 32	319 378 59
Additional investment solar equipment dollars (5)	270	135	235
Ratio (4) / (5)	1.70	1.54	1.61

(2) - Average estimated value on basis of data in Table 1. Corresponds to importer countries of the region.

(3) - Value of caloric equivalent of water heater affected by the losses and consumption up to the refinery gate.

(5) - Additional investment values determined in point 3.1.1.

Source: Fundación Bariloche, own calculations.

zone respectively.*/

At all events, they constitute reasonable periods to obtain financing which is paid for with the saving in importation.

3.2.2. Systems based on electrical energy

In this case, taking the values given in the previous points, the corresponding estimate can be carried out as follows:

In this instance, the set of investments necessary and the present value of the importations represent between 6.83 and 8.25 times more than the additional investment in the solar system, these values being all higher than the electrical case with local fuel production.

3.3. Importation of liquefied gas

This represents the extreme situation in which the conventional system requires practically no investment additional to that which the user must make. However, allowance must be made for investments corresponding to unloading, transport, bottling and distribution of liquefied gas, from the unloading site to the user. Since the solar system also requires it but to a lesser extent, it will not be considered and only the present importation value of liquefied gas will be taken. That is 1140 dollars/t.o.e. for a period of 15 years and an actualization rate of 10% per annum.

Taking a yield of 0.5 for the hot water tank, and considering the consumption values in useful energy of the solar water heater given in part 3.1.1, the present value of the importation is 539, 240 and 445 dollars for each zone.

If compared with the values of additional investment for the solar water heaters the present value of liquefied gas importations is 1.9, 2.0 and 1.78 times greater respectively.

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*/ - With the 1981 oil prices these periods can be halved.

TABLE N° 4

CAPITAL REQUIREMENTS AND PRESENT VALUE OF IMPORTATIONS
(System with electricity)

	1st.Zone	2nd.Zone	3rd.Zone
Power plant Investment dollars (1)	944	700	944
Fuel importation requirements (2) t.o.e./year	1.0	0.45	
Present Value Importations dollars (3) (2) x 760 dollars/t.o.e.	760	342	660
Investment in Refining Transport and Distribution (2) x 140 dollars/t.o.e. dollars (4)	140	63	122
Investment plus present value (1) + (3) + (4) = = (5) dollars	1844	1113	1726
Additional investment solar system	270	135	235
Ratio (5)/(6)	6.83	8.25	7.35

In other words, the additional investment necessary to install the solar heater is recuperated with the present value of 5.4, 5.0 and 6 years of importation respectively.

4. Summary and conclusions

As can be seen in Table N° 5 the capital requirements and/or the present value of the importations is higher than the additional investment for the solar system in nearly all cases.

The exception is the conventional system with natural gas which is less capital intensive.

The same occurs with systems based on oil derivatives in high productivity countries (Mexico, Venezuela). In these two countries, the alternative advantage consists of the exportation of the caloric equivalent of the solar water heater and in this instance the present value of the exportations exceeds the investment requirements of the solar system.

Conversely, the conventional electrical system appears in all cases with capital requirements values several times higher than the solar system.

As regards fuel importation, whether crude or liquefied gas, it can be stated that the additional investments which the solar system requires are recovered with the saving of importations in periods which in none of the cases analyzed exceed 7 years (they vary between 5.0 and 7.0 years) taking an actualization rate of 10% per annum.*/

This means that even with commercial/bank type loans it would be feasible to finance the additional investment requirements of the solar system.

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*/ - With the 1981 oil prices these periods are halved.

TABLE N° 5

SUMMARY OF THE RELATIONSHIPS BETWEEN CAPITAL REQUIREMENTS OF DIFFERENT CONVENTIONAL SYSTEMS AND THEIR SOLAR EQUIVALENT

	1st Zone	2nd Zone	3rd Zone
I. Internal Supply			
1. Oil Derivatives	1.06	1.31	0.40*/
2. Natural Gas	0.62	0.75	0.20*/
3. Thermal electric energy	5.53	7.83	4.83
II. Importation (1)			
1. Crude			
a) Oil Derivatives	1.70	1.53	1.61
b) Thermal electric energy	6.83	8.25	7.35
2. Liquefied gas	2.00	1.78	1.90

*/ - If the saving of oil derived from the existence of the solar water heater is oriented towards exportation, the present value of those inputs is 35% higher than the solar system investment.

(1) - Investment requirements and present value (at 10% per annum) of importations are added.

To conclude this analysis, we would like to emphasize that our interest in putting forward these estimates is to clarify the problem conceptually and to point to a methodology of analysis which places evaluation of the economic convenience of solar energy within the ov rall framework of an economic system and not exclusively at the microeconomic, individual level of the end user.

In each particular case the calculations presented here will need to be done again with more precise, specific data in order to establish the exact relationships.

The macroeconomic analysis indicates the need to redirect the flow of investments in conventional energy systems to other sectors of the economy (end consumer, construction industry, etc.) creating suitable financial mechnnisms for the purpose.