Project no. EIE/04/059/S07.38622

"ST-ESCOs"

Development of pilot Solar Thermal Energy Service Companies (ST-ESCOs) with high replication potential.

Intelligent Energy – Europe (EIE)

Type of action: SAVE

Key action: Buildings Sector

Pre-feasibility study HOSPITAL

(Generic - "Unfavourable")

Project coordinator
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Pre-feasibility study of a solar thermal ESCO application for a hospital

This study has been accomplished in the ambit of the EIE ST-ESCOs

Scope of this study – Summary

The following text consists of a pre-design study in technical, energy and economic terms. Its scope is to examine the feasibility of a solar thermal installation that will provide sanitary hot water under an ESCO (Energy Service Company) contract.

This means that the End User (in this case a hospital) will not invest (except from a small amount) for the construction of the solar plant, but will buy the heat from it at a convenient price. Moreover, the whole responsibility for the correct operation and the maintenance of the solar plant will be carried out by the ESCO, i.e. the Company that will undertake the construction and the management of the plant.

In this way, the hospital has direct economic benefits buying heat at an advantageous price without facing any technical risk.

Although this is not a detailed study, all main parameters from the technical side (plant components and energy yield) as well as from the economic one (terms of contract and benefits) are presented.

This study has been prepared and offered to the stakeholders in the ambit of the European project "ST-ESCOs" (Solar Thermal Energy Service Companies) that aims at the promotion of ESCO agreements for solar thermal plants in Europe. More information about the project, its partners (from Greece, Italy, Spain and Austria) and the material offered (market assessments, successful applications, feasibility studies, Policy Paper, software tool for ESCOs developers etc.) can be found in the web site www.stescos.org.

The system proposed by this study is a solar thermal system for the production of sanitary water; this system will save part of the conventional fuels consumption of the End User. The term "End User" in this study is used for the final consumer (i.e. the hospital in our case).

The results of the present study are summarized in the following table:

Solar collectors total surface proposed	1220 m^2
Total (roof) surface needed for the collectors field	3050 m^2
Total storage volume of solar plant	70 m^3

Annual solar yield delivered to the user	685 MWh
Overall benefit (NPV) of the User	91342 €
Duration of contract	20 years
Date of study's preparation	December 2006

End User description

The following table presents the basic information of the current End-User situation.

Name and category	Hospital
Indication of End-User's dimension (e.g. number of beds for hotels and hospitals)	800 beds
Mean Occupancy percentage in summer months	80%
Mean daily sanitary water consumption on summer days	91800 litres
Available surface for the installation of solar collectors	7250 m^2
Conventional fuel used	Natural Gas
Price of conventional fuel for the End-User	0,0363 €/ kWh
Available storage tanks for connection with the solar plant	No
Other important aspects or comments	The End-User has high sanitary water consumption and a large roof area available. Therefore, it is appropriate for the application of a large solar thermal plant. The current study has shown that an ESCO agreement is feasible and highly recommended (assuming a 40% of National financing).

More details about the hospital can be found in the questionnaire that has been prepared for the purposes of this study and filled in by the end user. The questionnaire has been included in Annex 4.

Solar plant description

The proposed technology is a central large scale solar heating system for sanitary water preparation.

The data used in order to accomplish the study have been obtained from the questionnaire filled in by the consumer and from the simulations of the specific software program “STESCO” (prepared by Aiguasol in the ambit of “ST-ESCOs” project). This program can perform both energy calculations (i.e. simulations of the solar thermal plant) by the sub-program En-MO and economic evaluations by the sub-program Ec-MO.

The nearest meteorological data available have been used for the simulation.

It is important to note that the actual plant solar output can be slightly different from the software calculations. This is due to two reasons: firstly, the meteorological conditions may vary significantly from year to year and, secondly, the real plant’s operation can never be perfectly simulated.

However, the above uncertainty has been taken in consideration and security margins have been adopted so that the important parameters for the end user (e.g. the NPV of its overall benefit) are guaranteed.

The most important components of the solar plant (as seen in its basic drawing scheme included in Annex 1) are the following:

1. Solar collectors of total area equal to 1220 m^2. The dimensioning criterion for the solar plant is to maximize the energy need for sanitary water during summer (avoiding excess solar heat production). Selective flat plate collectors facing south with a slope of about 35degrees have been considered. The total field needed for the collectors installation should be about 2,5 times the collectors area (in order to avoid shading between the collectors’ rows), therefore equal to 1220 m^2 * 2.5 = 3050m^2. Conclusively, a roof or other available place of total free and non-shaded area of 3050 m^2 should be reserved by the End User.
2. The total storage volume should be equal to 60 m^3. This may consist of one single large tank or several smaller connected in parallel, depending on the available space and/or the possibilities for outside installation. The final decision is subject of a detailed study
3. The hydraulic circuit with the following parts:
   - Pumps
   - Heat exchangers
   - Pipes, valves and connection with the auxiliary heating source
4. The tele-monitoring and tele-control system with the possibility of fault alarms to the ESCO’s responsible for maintenance.

The detailed dimensioning of all components is subject of a detailed study that could follow if a positive decision for the ST-ESCO agreement arises.

Energy, economy terms and others benefits

As it is obvious, the proposed agreement with a Solar Thermal ESCO for the construction of a solar plant will ensure clean and cheaper thermal energy to the hospital. It has to be clear that the unique essential obligation for the End-User is to buy a certain amount of energy per year from the ESCO (this is called "Energy under guarantee" in the study). On the other hand, the ESCO Company is obliged to maintain the price of the thermal energy that provides equal to the amount agreed (the one that appears on the table) independently of the solar system performance (i.e. even if, due to a special reason, the solar system is not working).

Different scenarios can be adopted concerning the exact dimensioning of the plant and the contract terms e.g. the contract duration. The terms presented refer just to one option that could be further elaborated in the ambit of a detailed study in order to better suit the End-User needs. Selected parameters and results are presented in the following table. The complete energy and economy analysis' results have been included in Annex 2 and 3 respectively.

Quantity	Value	Explanation/ comments
Solar yield	**685 MWh**	Is the annual thermal energy delivered from the solar plant to the End Users' consumption; it should be divided by the overall efficiency of the conventional thermal system (e.g. 85%) in order to obtain the total thermal energy saved by the solar plant.
Energy under guarantee	488 MWh	It is the minimum annual amount of energy that the End-User is obliged to buy from the ST-ESCO (i.e. the Company that sells the solar energy).
Total End-User's load	**1360 MWh**	It is the total annual consumption of the End user for sanitary hot water only.
Solar fraction	**50,4 %**	This is the annual fraction of the thermal needs for the sanitary hot water that are covered by the solar plant.
Contract period	20 years	The contract period could be shorter. The annexed economic analysis shows terms as the NPV year by year. Obviously, a 20 years contract offers higher benefit than a shorter one.
Contribution of the End-User to the investment	**15250 € (5%)**	This is a (minor) contribution of the End-User to the initial investment. The ST-ESCO contract is feasible also without this initial contribution. However, this reflects a minimum of interest from the End-User's side since it is a kind of guarantee for the ST-ESCO. Obviously, for the calculation of the NPV mentioned above, the repayment of this amount has firstly been considered.

Net Present Value (NPV) of the total economic benefit for the End-User	**91342 €**	The NPV of the benefit is the **NET** amount of End User's today's money that is equivalent to the total cumulated economic benefit of the End-User until the end of the ST-ESCO contract. (A simple example clarifying NPV: an End User pays 50 € in the first year and will have a benefit of 1100€ in one year. If his interest rate is 10%, the NPV of this investment will be equal to 950€. (Receiving 1100€ in a year is equivalent with receiving 1000€ today minus the 50€ of today's expenses equals to 950€)
Payback time	**≈ 4,3 years**	This is the real payback time for the End-User (taking into account the interest rates) and it can be clearly seen in the economic report of Annex 3
Cost of conventional thermal kWh for End-User (A)	0,0459 €/kWh	This calculated amount is the estimation of the real thermal kWh cost for the End-User (at present) according to the conventional fuel prices and to the conventional heating system efficiency.
Price of ESCO's thermal kWh for End-User (B)	0,04 €/kWh	This is the price of the kWh (at present) applied by the ESCO for the energy that will be delivered to the end user (as agreed in the contract).
Cost reduction	**13 %**	= (A-B)/A %
Annual increase in conventional fuel prices	**5 %**	This is a conservative hypothesis for the annual increase in conventional fuel prices based on last years' trend.
Annual increase in the price of energy delivered by the ST-ESCO	**3,5%**	This value is subject of negotiations. It could also be variable and equal to a fraction of the annual increase in conventional fuel prices.
Interest rate of End-User	5%	(called "Standard discount" in the economic report) Shows the variation of money's value with time for the End-User. For example, if the End-User is a private owner and can only put his money in a bank with 4% interest rate, then his interest rate is 4%.
Inflation	3%	Called "increase of consumer price index" in the report
Lifetime of the solar plant	more than 25 years	This is the expected lifetime of a modern reliable solar plant. It has to be underlined that since the optimized operation of the solar plant brings economic benefits to the ST-ESCO (as well as to the End-User), the ST-ESCO will seek for the best possible management of the plant, therefore maximizing the solar plant's lifetime.
Property of the plant after contract period	End- User	The End-User will have the plant for free after the end of the contract period. In the option of a shorter contract, either the End-User buys the plant at a conventional price or it remains ESCO's property.

There exist also other benefits for the end-user that could not be easily quantified. With an efficient solar plant the End-User will have advantages in fulfilling existing and new Energy and Environmental EC and national obligations (e.g. EPBD-European directive on the energy performance of buildings). Moreover, having a solar plant, the End-User shows a modern and environmental friendly profile. Other indirect benefits are:

- More autonomy from the conventional energy sources: weaker dependence on the availability and the price variations of the conventional fuel.
- Economic benefits due to the increase of service life for the conventional energy supply system and also to the reduction of its ongoing operation costs.

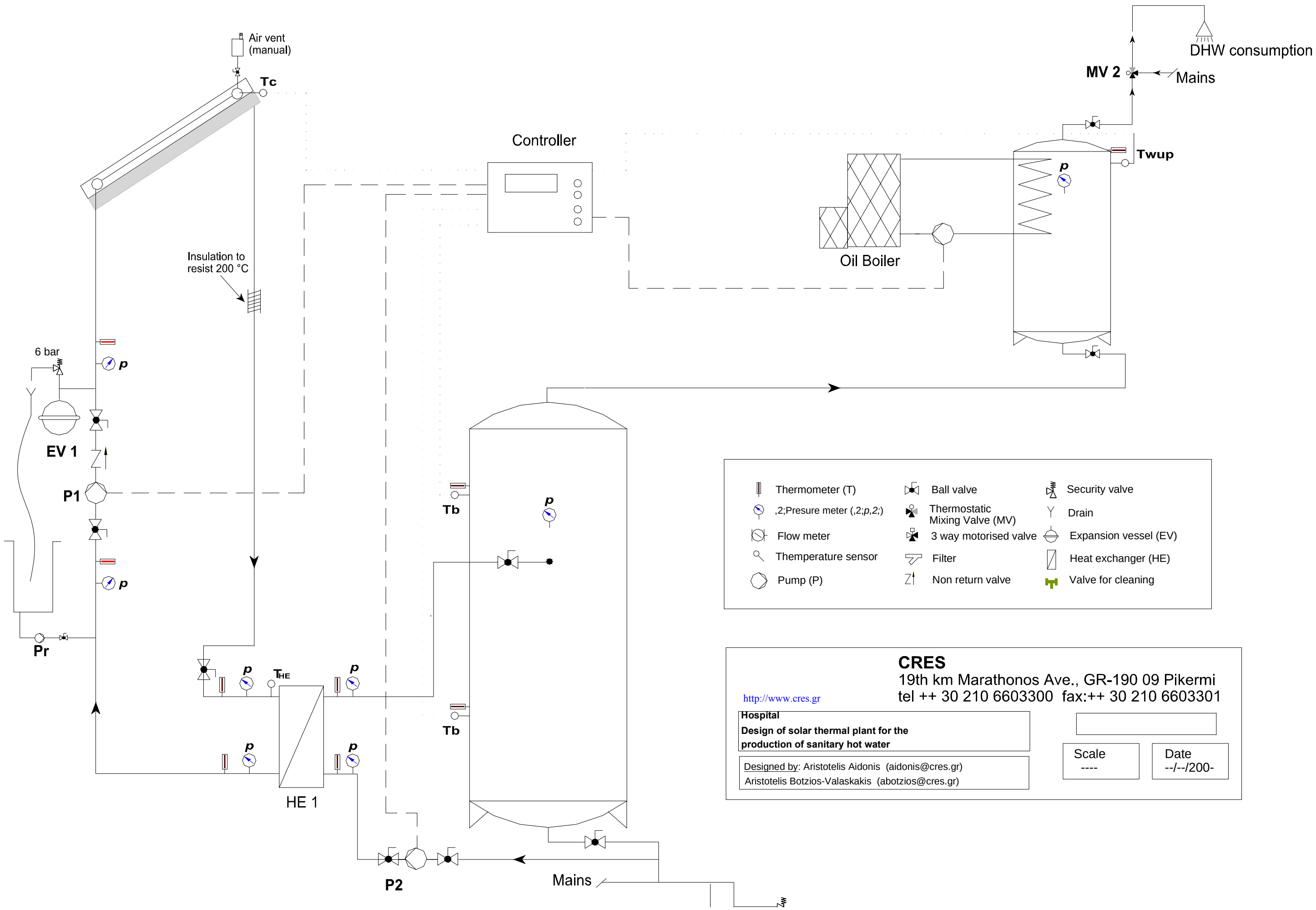
Finally, it has to be mentioned that the ST-ESCO could undertake the service for the whole thermal needs of the End-User and combine the solar plant with other energy service measures offering an overall energy management with higher economic benefits for the user.

Additional data (regarding only the ST-ESCO)

The ESCO developer will have a substantial economic benefit as it can be seen from the subsequent table where the major economic terms are presented. The ESCO has to guarantee the price of the thermal energy provided to the user, independently from the solar energy production. This means that the solar plant should work well and provide at least the "guaranteed kWh" in order for the ESCO to have benefits. Experience has shown that this is not a limitation but a challenge for further benefits for the ESCO, since the optimized solar plant will produce much more energy than predicted.

Total cost of the plant	305000 € (250 €/m^2)
Subsidies	122000 € (40%)
Contribution of the ST-ESCO to the initial investment	**76250 € (25%)**
Net Present Value of the total economic benefit for the ESCO	**190990 € (20y)**
IRR of ESCO	**28,1 %**
Payback time	**≈ 5,5 years**
Bank loan	91500 €
Bank loan interest rate	6 %

ANNEX 1 Basic solar plant drawing


Air vent
(manual)
Tc
Controller
Twup
MV 2
Mains
DHW consumption
Oil Boiler
Insulation to
resist 200 °C
6 bar
EV 1
P1
Pr
Tb
Tb
THE
HE 1
P2
Mains
Thermometer (T)
,2;Presure meter (,2;p,2;)
Flow meter
Themperature sensor
Pump (P)
Ball valve
Thermostatic
Mixing Valve (MV)
3 way motorised valve
Filter
Non return valve
Security valve
Drain
Expansion vessel (EV)
Heat exchanger (HE)
Valve for cleaning
CRES
19th km Marathonos Ave., GR-190 09 Pikermi
tel ++ 30 210 6603300 fax:++ 30 210 6603301
http://www.cres.gr
Hospital
Design of solar thermal plant for the
production of sanitary hot water
Designed by: Aristotelis Aidonis (aidonis@cres.gr)
Aristotelis Botzios-Valaskakis (abotzios@cres.gr)
Scale

Date
--/--/200-

ANNEX 2 Energy results from EnMo

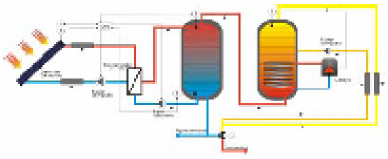
STESCO_EnMO V1.2

SIMULATION REPORT

Code	*HOSPITAL*
Name	
System	*Thessaloniki*
Address	*0*
City	*0*
Region	*0*
Phone/Fax	*0*
E-mail	*0*

1 System

Solar direct system



2 Demand

N° substations	-	*1,0*
N° users	-	*240,0*
Daily consumption	l	*91800,0*
Daily profile	-	*DProfile.TXT*
Monthly profile	%	*1 / 1 / 1 / 1 / 1 / 1 / 1 / 1 / 1 / 1 / 1 / 1*

3 Location

Meteorological data	-	*Thessaloniki.dat*
Latitude / Longitude	°	*40,3 -23,0*
Cold water temperature	°	*8,2 / 7,9 / 9,2 / 12,8 / 16,8 / 20,2 / 21,5 / 22,8 / 22,1 / 19,4 / 15,7 / 11*

4 Solar field

Area	m^2	*1220,00*
Slope	°	*35,0*
Azimuth	°	*0,0*
Number in series	°	*3,0*
Field flow rate	$kg/h.m^2$	*40,0*
Primary flow rate	kg/h	*48800,0*

5 Collector

a_0	-	*0,794*
a_1	W/m^2K	*3,880*
a_2	W/m^2K^2	*0,010*
IAM	-	*0,09*
Test flow rate	$kg/h.m^2$	*130,0*

6 Solar and auxiliary storage

		SOLAR	AUXILIARY
Volume	m^3	*70,000*	*12,000*
Height	m	*12,830*	*4,000*
Thickness	m	*0,100*	*0,050*

7 Auxiliary heater

Power	kW	*1 000,00*
Efficiency	%	*0,85*

ANNEX 3 Economy calculations from EcMo

ST-ESCo ECONOMICAL MODULE (EcMo)

V1.0

Bank report

1 PROJECT DATA

General data

Energy production analysis	[ ] Transol (Simulated)
	Project name
	[ ] Annual Mean (Estimated)
EcMo project name	Anonymous
EsCo	CRESCO
User	Hospital
Site	Thessaliniki
Variant IFCA	Model
Comments	--

2 SYSTEM DATA

Basic system description

Plant size (m²)	*1220,00*
Plant net specific output (kWh/m²*year)	*561,46*
Hot water consumption (l/day)	*0,00*
Hot water temperature (°C)	*0,00*
Cold water temperature (°C)	*0,00*
Service life of solar plant (year)	*0,00*
Decrease of solar plant energy output (%)	*1,00*
Net energy demand (kWh/year)	*1336789,10*
Net solar output (kWh/year)	*684984,09*

Conventional system description

Fuel of conventional system	*Natural Gas*
System efficiency (%)	*80,00*
Conventional energy price (€/kWh) (CEP)	*0,036*
Circulation losses (%)	*2,00*
Decrease in conventional boiler efficiency (%)	*1,00*

Economic data

Total investment cost (€)	*305000,00*
ESCo contribution to investment (€)	*76250,00*
User contribution to investment (€)	*15250,00*
Subsidies (€)	*122000,00*
Total financing amount (€)	*91500,00*
Credit account period (years)	*20,00*
Interest (%)	*6,00*
Specific investment cost (€/m²)	*250,00*

ANNEX 4 : Questionnaire filled in by the End-User

ΚΕΝΤΡΟ ΑΝΑΝΕΩΣΙΜΩΝ ΠΗΓΩΝ ΕΝΕΡΓΕΙΑΣ
19 ° χλμ. Λεωφ. Μαραθώνος, Πικέρμι Αττική
Τηλ: 210 6603300, Fax: 210 6603301-2
e-mail: cres@cres.gr, http://www.cres.gr

ΕΡΩΤΗΜΑΤΟΛΟΓΙΟ

Σκοπός: *εκπόνηση προμελέτης θερμικού ηλιακού συστήματος σε νοσοκομείο για την παραγωγή ΖΕΣΤΟΥ ΝΕΡΟΥ ΧΡΗΣΗΣ.*

ΜΕΡΟΣ Α (ΓΕΝΙΚΟ)

1. Όνομα και διεύθυνση του νοσοκομείου:
   Νοσοκομείο
2. Στοιχεία υπεύθυνου επικοινωνίας (ονοματεπώνυμο, τηλέφωνο, Email):
3. Ποια είναι η συνολική του δυναμικότητα (αριθμός κλινών); *800.*
4. Ποιος είναι ο μέσος όρος της πληρότητας (%) τους καλοκαιρινούς μήνες; *80,33%.*

(Σε περίπτωση που είναι γνωστά περισσότερα στοιχεία για την πληρότητα – όπως π.χ. η πληρότητα ανά μήνα για ένα χαρακτηριστικό έτος – παρακαλούμε να μας τα διαθέσετε σε ξεχωριστή σελίδα).

ΜΕΡΟΣ Β (ΤΕΧΝΙΚΟ)

1. Εκτιμήστε την μέση ημερήσια κατανάλωση του ζεστού νερού τους καλοκαιρινούς μήνες. Ποια είναι η θερμοκρασία διανομής του ζεστού νερού, π.χ. ο θερμοστάτης του μπόιλερ σε τι θερμοκρασία έχει ρυθμιστεί; (Παράδειγμα: κατανάλωση 2500 λίτρα τη μέρα σε 50 βαθμούς Κελσίου)
   Μέση ημερήσια κατανάλωση ζεστού νερού (το καλοκαίρι, σε λίτρα): *91.800.*

   Θερμοκρασία διανομής ζεστού νερού (σε βαθμούς Κελσίου): *48,5^{o}C.*
2. Τι είδους στέγη έχει το νοσοκομείο; (είναι επίπεδη κεκλιμένη ή μικτή;)
   Επίπεδη.
3. Αν η στέγη είναι επίπεδη, πόση ελεύθερη επιφάνεια υπάρχει (σε τετραγωνικά μέτρα) για την εγκατάσταση ηλιακών συστημάτων; *≈ 7.250 m^2.*
4. Στείλτε μας ένα πρόχειρο σκίτσο κάτοψης της στέγης όπου να φαίνονται οι κύριες διαστάσεις της και τα πιθανά «εμπόδια» όπως απολήξεις καπνοδόχων, φωταγωγών, κλιματιστικά κλπ. Σημειώστε τον προσανατολισμό (την κατεύθυνση του βορρά). Αν η στέγη είναι κεκλιμένη (π.χ. κεραμίδια), σημειώστε την κλίση της.
5. Περιγράψτε το σύστημα παραγωγής ζεστού νερού που διαθέτει το νοσοκομείο:

a. Υπάρχει ξεχωριστός λέβητας για το ζεστό νερό χρήσης (ναι, όχι) *Όχι.*
b. Τι χρονολογίας είναι (ή πότε εγκαταστάθηκε;) ------
c. Το ζεστό νερό παράγεται μέσω ατμολέβητα ή κοινού λέβητα;

   Κοινοί λέβητες και εναλλάκτες TANK-IN-TANK.

d. Τι ισχύ έχει ο καυστήρας (π.χ. 100.000 kcal/h); *3 X 2.800.000 Kcal/h.*

e. Τι καύσιμο χρησιμοποιείται; *Φυσικό Αέριο.*
f. Ποιο είναι το κόστος του καυσίμου για το νοσοκομείο; (δώστε μια μέση τιμή κόστους αγοράς κατά το τελευταίο έτος π.χ. 50 λεπτά το λίτρο πετρελαίου)
   0,0332663 € + ΦΠΑ (9%) / KWh.

g. Υπάρχει μπόιλερ (δοχείο) για το ζεστό νερό χρήσης; Αν ναι, τι χωρητικότητα έχει (σε λίτρα);
   10 Εναλλάκτες Νερού tank-in-tank συνολικής χωρητικότητας 4.000 lt περίπου.
h. Συμπληρώστε τον παρακάτω πίνακα με τις μηνιαίες τιμές κατανάλωσης καυσίμου (π.χ. λίτρα πετρελαίου) για ένα τυπικό έτος. Σε περίπτωση που σας είναι αδύνατο να εκτιμήσετε την κατανάλωση καυσίμου που αφορά μόνο το ζεστό νερό χρήσης, τότε καταγράψτε την συνολική κατανάλωση καυσίμου και περιγράψτε ποιες άλλες χρήσεις αφορά (π.χ. θέρμανση χώρων). Είναι σημαντικό να δώσετε όσο το δυνατόν πιο ευκρινείς και αναλυτικές πληροφορίες.

Ιανουάριος	Φεβρουάριος	Μάρτιος	Απρίλιος	Μάιος	Ιούνιος
2.786.000 KWh	*2.820.000 KWh*	*2.490.000 KWh*	*1.670.000 KWh*	*1.034.000 KWh*	*804.000 KWh*
Ιούλιος	Αύγουστος	Σεπτέμβριος	Οκτώβριος	Νοέμβριος	Δεκέμβριος
643.000 KWh	*645.000 KWh*	*658.000 KWh*	*1.502.000 KWh*	*2.595.000 KWh*	*3.111.000 KWh*

6. Σχόλια - παρατηρήσεις σας:

   Η κατανάλωση καυσίμου αφορά την θέρμανση (από Οκτώβριο έως και Απρίλιο), την ατμοπαραγωγή (2.000 kg/h X 8 ώρες ημερησίως X 365 ημέρες / έτος) και την θέρμανση νερού χρήσης.