Report No. 13485-TUN

Tunisia
Solar Water Heating

Project Document
October 1994

CURRENCY EQUIVALENTS
(as of July 1994)

Currency Unit	=	Tunisian Dinar (DT)
1 DT	=	1.0157 US$
1 US$	=	0.9845 DT

UNITS AND MEASURES

1 MJ	Mega Joule	1000 kJ 0.239 kcal
t	tons	
toe	ton of oil equivalent	42.7 MJ

ABBREVIATIONS AND ACRONYMS

AME	Agence pour la Maîtrise de l'Energie
GEF	Global Environment Facility
GHG	GreenHouse Gasses
ICB	International Competitive Bidding
SWH	Solar Water Heating
CO_2	Carbon dioxide

FISCAL YEAR 1995

Republic of Tunisia
Fiscal Year
January 1 - December 31

TUNISIA

SOLAR WATER HEATING PROJECT

GRANT AND PROJECT SUMMARY

Recipient:	Republic of Tunisia
Beneficiaries:	- Commercial private and public establishments in all sectors except agriculture and industry : hotels, municipalities ("collectivités locales"), mosques, turkish baths, schools, sports centers, multifamily residential buildings - US $ 6.6 million - AME: for promotion, procurement and monitoring activities - US $ 700,000
Amount:	SDR 2,8 million equivalent (US$ 4 million)
Terms:	Grant
Associated Bank Project:	Free-standing
Cofinancing:	BEF 105 million from the Kingdom of Belgium (equivalent to US$3.3 million).
Objectives:	The objectives of the Project are to assist the Recipient in encouraging the substitution of renewable solar energy for fossil fuels in public and commercial private institutions so as to mitigate global warming by maximizing co_2 displacement and demonstrate the potential of solar water heating for reducing global warming.
Project Cost:	US$ 20.9
Financing Plan:	GET: US $ 4.0 million Belgian Cofinancing: BEF 105 million (equivalent to US$3.3 million) Beneficiaries through commercial financial institutions or other private sources of financing: US $ 13.6 million
Economic Rate of Return:	n.a.

TUNISIA

SOLAR WATER HEATING PROJECT

Background.

1. Tunisia is likely to become a net energy importer by the year 2000. Its 36 million toe of oil reserves will be close to depletion before the turn of the century, and in ten more years also its 80 million toe of gas reserves will probably be exhausted. Currently 73% of total gas supply in Tunisia is imported from the Trans-Mediterranean pipeline. Energy demand is rapidly growing: projected average rates of growth across different sources of energy range between 4 and 6% per annum.

2. Tunisian dependence on hydrocarbons contributes to global environmental degradation in the form of CO_2 emissions. Commercial energy demand is met primarily by petroleum products (78%), followed by electricity (11%) and gas (9%). Electricity is generated from petroleum, natural gas and diesel. Tunisian authorities are concerned with both long-term energy management and with the environmental impact of energy use. The Eight Plan (1992-1996) calls for a reduction on reliance on imports and for increased emphasis on conservation and renewable energy as well as demand side management based on least cost planning. In the residential and tertiary sectors, energy management strategies include promotion of energy efficiency and fuel substitution using least-cost sources. More detailed information about the energy sector and subsectors as well as solar energy use in Tunisia is provided in the Annex I.

3. In contrast to the declining fossil fuel resource base, Tunisia has a substantial solar resource base, with sunlight available between 2863 and 3326 hours per year. The average daily insolation ranges from 4.5 kWh/m2 to 5.2 kWh/m2 across the country. The ratio between observed insolation and the potential (theoretical) maximum insolation (insolation index) varies between 64 and 75%. For example, the same index in France ranges between 37 and 66%. Solar energy for water heating is already used in Tunisia in the residential and hotel sectors: it presently covers 1% of hot water demand whereas countries in the same region such as Cyprus cover 60%. The total potential market for solar water heating in the residential sector is estimated to be 40% and 60% for the hotel sector. This covers retrofit as well as new installations.

4. Tunisia has several years of experience with the SWH technology (see Annex II for a description of the experience). The one local parastatal company, Serept Energies Nouvelles (SEN), has supplied SWH systems for a total of about 30,000 m2 of collector area, mainly to the residential sector.The Energy Conservation and Demonstration Project (LN 2735 TU) recently commissioned a 160 m2 SWH system through ICB for a hospital in Gafsa. This installation, once operational, will constitute a demonstration case for the hospital subsector, yielding thus better cost and benefit estimates than are available now. The 420 m2 SWH system in the Sultan hotel in Hammamet that was installed by SEN in 1988, will be brought back to working condition and monitoring equipment should be installed so that it can function as another demonstration case, for the hotel subsector.

GEF activity objectives.

5. The main objectives of the project are to encourage the substitution of renewable solar energy for fossil fuels in all sectors except agriculture and industry and thus mitigate global warming by maximizing CO_2 displacement and demonstrate the potential replicability of the selected approach - SWH - for reducing global warming.

Project scope and GEF activity description

6. Several factors constrain the market penetration of SWH in Tunisia. They fall under the following categories: a) technology - local producers have so far almost only catered to individual households and are not in condition to serve a larger-scale, more sophisticated demand; b) price - the low price of alternative sources of energy makes choosing renewable energy a difficult economic choice; c) market conditioning/awareness - marketing and awareness campaigns encouraging renewable energy use have not been sufficiently effective;

d) general obstacles to a competitive market - some fiscal distortions have affected in the past the development of a competitive market.

7. The project will contribute to the reduction of these constraints and favor the development of a market for SWH technology. Economic appraisal (see Annexes) has shown that currently in Tunisia investment in SWH constitutes an economically viable choice (either for retrofit or for replacement of other means to heat water) when it does not directly compete with natural gas. In the cases where fuel oil or electricity are used to heat water, and assuming that SWH equipment enjoys the favorable tax and duty treatment foreseen by the new Investment Code (only 10% duty on imported equipment), a subsidy of 35% of the cost of investment before tax is sufficient to generate a high internal rate of return and makes the SWH choice attractive.

8. The project consists of two components: a) a technical assistance component, which finances promotion and marketing activities, international procurement of equipment to guarantee the selection of technologically efficient and price-competitive equipment, and monitoring of the project implementation and its impact in terms of market penetration and the environment; b) an investment component, in the form of a 35% subsidy to the cost of investment in SWH, which will make the decision of investing in SWH economically attractive to potential users and provide the seed for the development of a self-sustained market.

9. The project intends to promote the commercialization in Tunisia of the environmentally benign SWH technology. It will target establishments that (a) have a high demand for hot water, mainly hotels, municipalities, hospitals, public sports centers, schools, mosques, and multifamily (residential) buildings; and (b) do not have access to natural gas. The project will address new as well as retrofit clients. Investments in SWH systems are already marginally economic, with rates of return ranging from 10 years to over 20 years.

10. The project consists of two components:

a) <u>Technical assistance component (US $ 700,000)</u>, which will finance:

* organizing and carrying out product promotion and publicity, to increase market awareness;

* preparing the ICB procurement in packages; this includes training for private Tunisian consulting firms and AME, in order to more professionally predetermine the size, costs, and prospective benefits from installing a SWH system at a particular site. In addition, technical assistance will be provided to AME to fully comply with standard Bank procurement procedures;

* monitoring the performance of SWH systems, from the technical, economic, and environmental points of view; this includes keeping records of achievements to date, including the total amounts of CO_2 avoided, and the average costs for doing so; carrying out a forward-looking evaluation of the SWH systems installed in all selected commercial private and public establishments in Tunisia and in a sample of the residential systems, to identify the constraints to improved monitoring and maintenance. End-users will collect data on a daily basis, which will be compiled and analyzed by AME on a quarterly basis.

b) <u>Investment in SWH equipment by targeted users of US$ 6.6 million)</u>: the GEF fund, together with Belgian cofinancing, by contributing with 35% of the cost of investment before tax in SWH (including installation), will leverage a total of US $ 20.9 million, of which 13.6 (representing the remaining 65% of the cost of investing in SWH) will be provided by the beneficiaries either through borrowing or self-financing. This amount will allow the project to finance about 150 tailored packages for SWH installations over a period of 10 years, and will constitute the trigger for the development of a self-sustaining market for SWH in Tunisia.

Project beneficiaries

11. The direct beneficiaries of the GEF grant are the final users of SWH: hotels, schools, sports centers, and large multifamily buildings through real estate developers. Subsidies are provided to motivate users to invest in SWH rather than in conventional water heating technologies. A successful implementation of the project implies about 150 subprojects of an average size of US$ 200,000. The Tunisian economy is a beneficiary as well, as less fossil fuels are used to heat water. Although at the moment Tunisia is exporting petroleum products, in the near future it will become a net importer of conventional energy products and the use of SWH technology will encourage the diversification of energy sources. The global environment is the final beneficiary, as less greenhouse gasses will be emitted into the atmosphere.

Project implementation mechanism

12. The recipient of the grant is the Republic of Tunisia. The recipient has selected AME as the project executing agency. A special account will be opened at the Central Bank of Tunisia. AME will be the beneficiary of the first component of the grant, which will cover its expenses as promoter, procurement agent and supervisor of the project, and will be responsible for the administration and audit of the account for the investment component. AME role will be limited to acting as an intermediary in the financing of the SWH equipment packages. Upon receipt by AME of suitable evidence of the expenditures to be financed by the grant, AME will automatically process the withdrawal applications. To those ends, a suitable team shall be maintained within AME throughout the period of Project implementation under terms of reference satisfactory to the Bank and consisting of technical specialists with qualifications and experience satisfactory to the Bank.

13. Potential SWH users become automatically eligible for obtaining the GEF subsidy by demonstrating that they have secured private financing for the purchase and installation of the SWH system (minus the potential subsidy). In order to obtain the subsidy, the final user will first submit to AME a standard form which includes basic site parameters, civil works' plans and timetables for the installation of SWH equipment. The form will only contain basic information on the site of the prospective installation and on the demand to be satisfied, as well as the basic parameters of expected performance from the equipment based on the hot water demand profile. A rough estimate of the cost of the SWH system and its benefits is made at this time, and GEF's future contribution is estimated.

14. Once these basic parameters are determined, and the user has shown to have access to financing, the user will be automatically eligible for the GEF grant. The subsidy portion (35% of before tax of the estimated cost of the equipment) will be directly paid to the supplier according to the payment schedule specified in the contract, which has been established to be divided in three tranches of 10, 80 and 10%. AME, as procurement agency, will invite international competitive bids for the provision of the required equipment, preferably for several installations at the same time to obtain economies of scale. The selected supplier will provide the specific design of the installation and discuss this with the user directly. He should not deviate from the basic performance parameters, but is welcome to suggest several alternative designs as long as he specifies the expected performance. The supplier will be paid through commercial financing and by the GEF and Belgium grants directly.

15. It is important to notice that, once the beneficiary (hotel, school, etc.) has filled the preliminary standard form and produced evidence of its ability to provide the remaining 65% for the purchase of the equipment, its request is automatically eligible, and no review or judgement will be needed in order to allow the release of the funds. The Bank will review groups of bids every six months. The technical specification of the equipment to be installed will be provided by the supplier.

16. Users will be offered an additional incentive through the performance guarantee (up to a prespecified period, to be given by the supplier) for the use of SWH systems installed with GEF assistance. The earlier SWH experience strongly suggests that this guarantee be required. All equipment to be financed under this project will be subject to International Competitive Bidding. The bidding documents will include a description of the maintenance services requested under this guarantee. In principle, during a prespecified period, the supplier of the equipment will need to demonstrate that the SWH installation indeed performs according to the specifications.

Project cost and financing.

17. The project is financed by a US$ 4 million grant from the GEF and by Belgian cofinancing for BEF 105 million (equivalent to US$ 3.3 million), while the private sector is expected to generate an additional US$ 13.6 million during the life of the project, and much larger sums afterwards through private sector financing. The grant cum cofinancing will provide a fund of about $6.6 million to provide financial assistance to the final users for individual purchases and installations of solar water heating systems, and will finance a technical assistance component of US$ 700,000 mainly for support activities. As the grant only finances 35% of the costs before tax of SWH equipment, final users will make available the remaining US$ 13.6 million through commercial lending institutions. Total project cost thus amounts to US$ 20.9 million. Estimated costs and financing plan are described in detail in Schedule A.

Procurement

18. A table in Schedule C summarizes procurement arrangements for the grant. AME will carry out all procurement of the project in accordance with the Guidelines for Procurement under IBRD Loans and IDA Credits, of the Bank, dated May 1992. Standard bidding documents have been prepared by AME and reviewed by the Bank.

19. Goods. To the extent possible, contracts for goods (SWH equipment for a total amount equivalent to US $ 20.9 million) will be packaged appropriately. Procurement of contracts estimated to cost the equivalent of $ 250,000 or more would require the Bank's prior review. All procurement of goods will be ICB. The selection criteria agreed upon with AME are: price, price of spare parts (for two years), technical specifications, guarantee of performance of the equipment, after sale service.

20. Services. Part of the technical assistance funds made available to AME can be used for hiring consultants for training on Bank procurement of either AME staff or any procurement agent to whom AME decide to sub-contract part of the procurement task. These consultants' services are included under the technical assistance component. The cost of each of these services and the amounts involved will be small (below US $ 100,000). Thus consultants will be directly retained by AME and their TORs will be reviewed by the Bank. Contracts for consulting firms estimated to cost over $100,000 and for the employment of individual consultants estimated to cost over $50,000 and all terms of reference would require prior Bank review. Employment of consultants shall be carried out in accordance with the Bank's Guidelines on Use of Consultants by World Bank Borrowers and by The World Bank as Executing Agency, dated August 1981. AME will be required to submit, not later than October 31 each year, a yearly work program to the Bank for the use of the technical assistance funds for the following year. A team will be appointed within AME, specifically responsible for the recruitment and supervision of the technical assistance component.

Disbursement

21. A special account will be opened at the Central Bank of Tunisia. The special account will carry funds equivalent to four months of projected expenditures in an aggregate amount of US$ 700,000. It will be replenished each time funds are near depletion. The funds deposited in the special account will cover both the technical assistance components such as AME expenditures for promotion, procurement and monitoring, and the subsidy to the cost of investment

in SWH. Details on disbursement are described in Schedule B. The recipient shall cause AME to appoint auditors acceptable to the Bank for the auditing of the special account.

Rationale for GEF funding and contribution to GEF portfolio.

22. The present cost of water heating in the targeted sector in Tunisia, using conventional sources of energy (particularly natural gas, but also fuel oil), makes environmentally benign SWH economically unattractive from the point of view of the individual investors. The supply of natural gas is limited to certain geographical areas, and some of the main tourist areas are not in that zone. The GEF grant will help make SWH attractive to the fuel oil user by reducing upfront costs of the investments through a direct subsidy thereby improving the rate of return on the investment and reducing the payback time. This is likely to result in a relatively large volume of SWH equipment to be sold and used in Tunisia (See Annex 3, Table 6 for market projections), whereby scale economies can be gained while the infrastructure for repair and maintenance will improve, thus facilitating long-term sustainability to the market penetration of SWH in Tunisia.

Global environmental benefits.

23. CO_2 emissions from the combustion of fossil fuels form a considerable contribution to the greenhouse effect in Tunisia. Global environmental benefits resulting from the use of SWH can be substantial: first, because SWH equipment once installed, can provide benefits over the service life of the equipment, at least for 15 to 20 years; second, since the GEF involvement is expected to trigger the commercial take-off of the market for SWH, giving rise to a multiplier effect. The technical feasibility and market studies carried out by international consultants and financed by a project preparation advance, suggested a conservative market penetration scenario, starting with 5,000 m2 of additional collector area per year in 1995 gradually increasing to 26,000 by the year 2015. Resulting avoided CO2 emissions would amount to 2,450 t in the year 1995, increasing to 125,000 t in year 2015. About 60% of the avoided emissions would come from the hotel subsector.

24. Total avoided emissions as a result of ten years of GEF intervention (accounting only for equipment that was subsidized by GEF) would amount to 636,500t. Total emissions through 2015, accounting also for equipment that has not directly been subsidized by GEF, would amount to 972,000 t, while total avoided emissions over the lifetime of all equipment that would be installed through 2015 amounts to over 2.5 million t of CO2. The proposed project would thus significantly reduce CO2 emissions for a total cost of US $7.3 million. This translates into an avoided cost of about $7.5 per ton of CO2 on a discounted cost basis, or $23 per ton of Carbon. Although these cost figures are not the lowest for GEF projects in the Pilot Phase, they are within acceptable limits. Taking into account the aforementioned multiplier effect and thus accounting for accrued benefits, cost of avoided emissions can be as low as DT 1.8 per ton.

25. In general terms, one m2 of collector area (for the hotel subsector, with a solar coverage of 74%, see Annex 3, Table 4) will avoid the following CO2 emissions in one year: 459 kg CO2 in case electricity is replaced, 362 kg CO2 if fuel oil is replaced, 231 kg CO2 if LPG is replaced, and 186 kg CO2 if natural gas is replaced. The energy pricing situation in Tunisia is such that substitution of SWH for natural gas or LPG is not feasible. In addition, environmental benefits are the highest for more expensive fuels such as electricity and fuel oil. This double effect causes the project to concentrate on those clients that have no access -- nor will have access in the near future -- to piped gas, but are using electricity or fuel oil.

Form of innovation.

26. The project is innovative since it will provide an unprecedented financial incentive to the introduction the SWH technology in Tunisia for the benefit of private and public large commercial users. This approach is new to Tunisia - where SWH has had some success in the individual household sector but has not been widely adopted by collective establishments - and on a worldwide basis - at least in terms of the size of the financial support offered to the sector. In addition, the method of financing entails the participation of private institutions and a loan portion to guarantee cost recovery and long-term sustainability to the initiative.

Demonstration value and replicability.

27. The lessons learned from the Tunisia SWH project can serve as a model to leverage penetration of solar energy in the targeted sector in other countries where market barriers presently exist. The institutional and financial mechanism put in place, with an important role given to financial institutions and private participants, is also an innovative feature that can be replicated in other countries. The use of competitive bidding procedures, and the willingness of the local producers and authorities to ensure a substantial reduction of the barriers to market competition are key elements in guaranteeing the demonstration value and replicability of this project.

28. The project will test the market for SWH for different scales of investment in different circumstances (electricity replacement versus fuel replacement), to adjust the minimum subsidy required for investors to choose the SWH option (now set at 35%). It will thus also allow the Tunisian authorities, once identified this minimum level in the present conditions of the market, to evaluate alternative policy options to enhance market competitiveness and SWH technology penetration. These could include either taxing other sources of energy to encourage fuel economies, lower tariff duties on imported solar equipment, or matching the GEF-provided subsidy on renewable energy with government funded incentives in the future (for example, make the subsidy to investment in renewable energy a permanent effort).

Sustainability.

29. The market penetration studies prepared by consultants as a basis for the project forecast that, after reaching a certain threshold in terms of m2 of collector area sold each year, the commercialization process will become self-sustaining. A key role in the success of this process will be played by the opening of the SWH market to increased local and international competition. Local financial institutions will mobilize a substantially larger amount of funds than the initial GEF grant, thus extending the horizon of impact of the project. Market competitiveness will be enhanced through the application of the exemptions foreseen by the new Investment Code for renewable energy related equipment and goods. The Recipient shall ensure, under any event (including if the Investment Code is obrogated), that the cost finally incurred by the Beneficiary for the SWH equipment financed under the Project equals the c.i.f. price of the imported goods plus a maximum 10% tariff with no VAT taxes. In addition, assurances have been obtained that the Recipient shall take at all times, during and after Project execution, all action necessary to maintain a financially competitive environment for the solar water heating industry adequate to encourage a sustainable penetration of said technology and guarantee a permanent reduction of the greenhouse gas emission. To this end, the Recipient and the Bank shall, from time to time, at the request of the Bank, exchange views with regard to the Recipient's incentives policies in the solar water heating sector and its plans in respect of the overall development of the sector.

30. Success of this pilot project will also be instrumental in guaranteeing the continuation of this effort from the Tunisian authorities. Therefore, the long-term sustainability of the effort will be increased through the initiatives that

the Tunisian government is putting in place for the support of renewable energies, with the endorsement of the President of the Republic, and which will become operational by the end of the century.

Monitoring and evaluation.

31. Until now, the existing SWH systems in the residential sector have not been monitored, and possible environmental benefits have been estimated rather than measured. Simple monitoring equipment (such as calorimeters, flow meters, thermometers, kWh or Nm3 meters for back-up systems) will be installed in all SWH systems financed under the project, and AME will ensure monitoring of performance and determine actual environmental benefits. Financial monitoring of the GEF fund will be ensured by AME and by the financial institutions involved. Agreement has been reached with the Government of Tunisia on the specific monitoring indicators to be employed for monitoring equipment performance and environmental impact during the execution of the Project and its operational phase. A report on this monitoring and evaluation activities shall be submitted by the AME not later than February 15 each year. Agreement has also been reached with the Tunisian authorities on carrying out not later than December 31, 1998 a mid-term review of the project with the Bank, which will inter alia evaluate AME processing and monitoring record and the success of the project in terms of market penetration of the SWH technology and environmental impact; this review will identify problems and obstacles and agree on actions needed to improve project implementation, including potential changes in project design.

Issues and risks.

32. Market penetration: the main issue and risk for the project consists in its demand-driven nature. After a careful economic appraisal, the mission has concluded that with a limited grant support (35% of the cost of investment including installation), targeting users who do not have direct access to natural gas, investors can expect high rates of return from investing in SWH equipment, and substantial market penetration will be reached during the next five years, with an important positive impact on the environment. However, exogenous factors could affect this calculation (general macroeconomic conditions, slump in tourism, etc.), and thus there could be a lack of new SWH clients willing to borrow from commercial banks or invest in SWH equipment. This could also happen due to occurrence of technical problems from lack of maintenance, or from the lack of technological improvements due to the absence of international competition.

33. This last concern is addressed by the project by demanding that maintenance operations be performed on a regular basis (promoting the idea of maintenance contracts), and by applying ICB on the one hand, and by providing technical assistance to the producer of SWH in Tunisia to improve the quality of his product line on the other hand -- if applicable. In addition, the publicity campaign to be launched and organized by AME is supposed to stimulate demand for SWH equipment. During the mid-term review foreseen, the extent of market penetration will be evaluated and other alternatives will be taken into consideration in the case of insuccess.

Agreed Actions

34. Agreements were reached with regards to the following matters: (i) maintenance of a project implementation team in AME for the implementation of the project; (ii) carrying out of a mid-term review of the project with the Bank, not later than December 31, 1998; (iii) confirmation of specific monitoring targets and evaluation methodology to be employed by AME; (iv) yearly submission by AME to the Bank of a yearly work program for the use of technical assistance funds; (v) in order to ensure the long-term sustainability of the Project, the Government of Tunisia shall take at all times, during and after project execution, all action necessary to maintain a financially competitive environment for the solar water heating industry adequate to encourage a sustainable

penetration of said technology and guarantee a permanent reduction of the greenhouse gas emission. To this end, the Government of Tunisia and the Bank shall, from time to time, exchange views on the incentives policies in the solar water heating sector and the government's plans in respect of the overall development of the sector. Furthermore, the Government of Tunisia shall ensure under any event, that the cost finally incurred by the Bank for the goods to be financed out of the proceeds of the GET Grant and the Belgium Grant equals the c.i.f. price of the imported goods plus a maximum ten percent (10%) tariff with no VAT taxes; and (vi) procurement of goods and employment of consultants shall be carried out in accordance with Bank's guidelines.

Conditions of Effectiveness

35. Conditions for grant effectiveness include the appointment of the implementation team for the project within AME and submission of the first yearly work program for the use of technical assistance funds for project support activities. Thereafter, this report should be submitted to the Bank not later than February 15 in each Fiscal Year (FY) beginning with the FY after the FY ending on December 31, 1995.

Conditions of Disbursement

36. The disbursement of the proceeds of the GET and Belgium grant shall be conditioned to the granting of the incentives and exemptions provided in the Investment Code to SWH equipment or the configuration that the cost incurred for such goods equals the c.i.f. price of the imported goods plus a maximum 10% tariff with no VAT taxes.

Project Implementation Schedule

37. It is expected that within three months from the date of signature of the grant agreement, the recipient will appoint the project team in AME and prepare the first yearly work program for the use of the technical assistance funds for project support activities. By December 31, 1998, AME will prepare a mid-term project implementation report, and a mid-term review will be performed with the Bank. All applications for withdrawal of funds from the grant will have to be presented on or before June 30, 2003. The project is expected to be completed by December 31, 2003. The closing date for the project shall be June 30, 2004.

Environmental classification

38. The primary objective of the project is to reduce greenhouse gas emissions and global warming by encouraging investment in environmentally benign SWH technology. Therefore the project will not have any adverse environmental impact. The environmental screening classification is "C" in accordance with O.D. 4.01, Annex A.

Poverty Category

Not Applicable

attachments

Washington DC
October 25, 1994

TUNISIA

SOLAR WATER HEATING PROJECT

Cost Estimate and Financing Plan[1]

Cost Estimate (US$ million)	Local	Foreign	Total
Capital Subsidies	2.64	3.96	6.60
Durable Equipment	5.44	8.16	13.60
Procurement	0.07	0.13	0.20
Product Promotion	0.27	0.13	0.40
Training	0.02	0.01	0.03
Monitoring	0.04	0.03	0.07
Total	8.48	12.42	20.90

Financing Plan (US $ '000)

Source	Local	Foreign	Total	% of TOTAL*
GET (installations)	1.53	2.12	3.30	15.80% [17.5%]
Belgium grant	1.53	2.12	3.30	15.80% [17.5%]
GET (T.A.)	0.40	0.30	0.70	3.40%
Beneficiaries	5.70	7.90	13.60	65.00%
TOTAL	8.76	12.14	20.90	

* Between square brackets, % of total installations' cost.

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1 Belgium grant amounts to BEF 105 million; cost estimates and disbursement plan have been converted into US$ for consistency.

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SOLAR WATER HEATING PROJECT

Estimated disbursement profile

(US $ thousand)

The projected disbursement flow is presented below over a ten year period after the beginning of the project. As the project facilitates a take-off of a commercial process that is supposed to grow over time, the disbursement profile is that of an emerging market rather than a standard Bank project. The project is expected to fully disburse in nine years.

Year contribution	Subsidy (35%)	Other	Private	Total	Cumulative
year 1	614	150	1,140	1,904	1,904
year 2	655	150	1,216	2,020	3,924
year 3	697	100	1,295	2,093	6,016
year 4	744	100	1,381	2,225	8,241
year 5	792	75	1,471	2,338	10,579
year 6	843	50	1,565	2,457	13,036
year 7	898	25	1,667	2,590	15,626
year 8	955	25	1,773	2,753	18,379
year 9	404	25	2,093	2,522	20,900
Total	6,600	7500	13,600	20,900	

DISBURSEMENT SCHEDULE (GET GRANT and Belgium GRANT)

The GET and Belgium grants will disburse pari passu and contribute with a total of 35% of the total cost before tax of solar water equipment (including installation).

	Amount of the grants allocated (US $ '000)	% of Total Expenditures to be financed
Consulting services studies, promotion and other activities by AME	700	100% of Local and foreign expenditures
Equipment: of which by GET grant	3300	17.5% of Local and Foreign Expenditures
of which by Belgium grant	3300	17.5% of Local and Foreign Expenditures
Total grant portion of expense in equipment	6600	35% of Local and Foreign Expenditures

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SOLAR WATER HEATING PROJECT

Standard Procurement Documents

Procurement documents complying with the Bank Guidelines and standard bidding documents have been finalized with the staff of AME during project appraisal.It was agreed with AME that ICB will be applied to all subprojects and that AME will launch international tender offers including projects for more than one installation at a time. The Bank will review a priori evaluation reports and contracts for all contracts which exceed US $ 250,000.This review will cover more than 60% of all Bank-financed procurement.

PROCUREMENT METHOD *

Category	amounts in(US$'000)	ICB	Other	Belgian Cofinancing	Total
1. AME expenditures for:					
	promotion:		400		
	procurement:		200		
	training/studies:		30		
	monitoring/evaluation:		70		
	Total		700** (700)		700 (700)
2. Equipment		13,600 (3,300)		3,300 *** (3,300)	16,900 (6,600)
3. Total		13,600 (6,600)	700 (700)	3,300 (3,300)	20,900 (7,300)

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* Numbers within parentheses represent amount financed by the GET and Belgium grants, the remainder being mobilized by the market

** AME expenditures and cost of consultants appointed under Bank Consultant Guidelines

*** Bank ICB procedure equally applies to Belgium grant

TUNISIA

SOLAR WATER HEATING PROJECT

Timetable of Key Project Processing Events

a)	Time taken to prepare project[2]:	24 months
b)	Prepared by:	MN1IE
c)	First Bank mission:	For new IEPS: 11/1992
d)	Appraisal mission departure:	June 3, 1994
e)	Negotiations:	October 17, 1994
f)	Grant approval:	November 1, 1994
g)	Expected date of effectiveness:	January 1, 1995
h)	Relevant PCRs:	N/A

2 The project was initially launched in 1991. The original project design however had to be completely revised after the first GEF review. The new IEPS was prepared in the Fall of 1992 and discussed on December 18, 1992. Thus the project preparation cycle of the revised project goes from Fall 1992 to Fall 1994.

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SOLAR WATER HEATING PROJECT

Bank Staff Inputs for project supervision through 1997

Date	Activity	Skill	Input (S/W)
4/95	Supervision Mission I First review of project implementation Review monitoring/ evaluation and procurement processing by AME	SWH expert ENV expert Procurement	2 2 2
1/96	Supervision Mission II Second review of project implementation (review of market penetration of SWH and identification of obstacles) Review monitoring/ evaluation and procurement processing by AME	SWH expert ENV expert Procurement	3 3 3
1/2000	Supervision Mission III Third review of project implementation (review of market penetration of SWH and identification of obstacles) Review monitoring/ evaluation and procurement processing by AME	SWH expert ENV expert Procurement	3 3 3
		Total S/W	24

Annex I

A. TUNISIA: ENERGY AND TERTIARY SECTORS

1. Energy Sector.

The energy sector is of considerable importance to the economic growth of Tunisia, although less so than in the early '80s. The value added of petroleum products and electricity accounted for 9.7% of GDP and 28.2% of gross industrial output in '88 and an average of 11.5% and 32% between '82 and '86. Tunisia is expected to remain a net petroleum exporter until the year 2000, unless new oil fields are discovered. Biomass (mainly firewood and charcoal) is still used, primarily in the residential sector and in rural areas. In '87, biomass accounted for 16% of the energy demand. The industrial sector is the largest energy consumer (37%) followed by the residential sector (27%) and the transport sector (25%). The tertiary and agricultural sectors each accounted for 6%.

a. Energy Supply

Primary energy supply in Tunisia is dominated by crude oil that for 88% comes from the two principal oil production fields. Oil is used for electricity generation and as feedstock for refineries. The production of crude oil is stagnating due to a limited resource base. Exports of surplus primary energy dropped from 3 million TOE in '80 to 1.6 million TOE in '87, and a deficit of 4 million TOE is projected for the year 2001. Reliable data on the resource base of biomass do not exist. It is estimated that a substantial part of the wood supply comes from maintenance operations in the agricultural sector (olive plantations).

The total supply of energy in 1992 was estimated by AME at about 6060 kTOE of which 23% consisted of biomass. Some 20% consisted of natural gas imported from Algeria. The availability of natural gas increased tremendously after '83 when the transcontinental gas pipeline between Algeria and Italy was commissioned.

Energy Supply in Tunisia (92, kTOE)

Type of Energy	kTOE
Petroleum Products	3352
Biomass	1400
Natural Gas	1220
Coke	74
Hydroelectricity	14
Total	6060

Source: AME

b. **Energy Demand**

The demand for energy increased at about an average of 4.4% per year during the period between '80 and '92. The growth in energy demand was higher than the growth of the economy except during the recent period of slow economic growth ('91-'92). The increase in electricity and natural gas consumption has been much higher and amounted to 7.7% and 12% per year during the same period.

By type of energy, consumption of petroleum products is the largest (69.3%), followed by biomass (16.2%), electricity (8.4%), and natural gas (6.0%). By sector, the industrial sector is the largest energy consumer (35.1%), followed by the residential sector (27.3%), transport sector (25.4%), tertiary (6.2%) and agriculture sector (5.9%).

Energy Demand in Tunisia ('87, kTOE)

Sector	Electricity	Petroleum	Natural Gas	Biomass	Total
Industry	152	893	178		1223
Residential	65	341	13	530	949
Transport			885		885
Tertiary	62	110	19	25	216
Agricultural	15	182		10	207
Total	294	2411	210	565	3480

Source: ESMAP

2. Tertiary Sector

Although the tertiary sector consumed about 6% of the final energy demand, the sector is growing rapidly because Tunisia devotes significant resources into developing it. As a result, the value added of this sector has risen at an average annual rate of about 11%.

The tertiary sector is made up of, inter alia, hotels, restaurants & cafes, Turkish baths, hospitals, schools, sport complexes & swimming pools, the administration, and public lighting. Of these, the hotel subsector consumes one-third of all modern energy consumed in the tertiary sector. The second largest energy consumer is the Turkish Bath subsector, which consumes 17% of the total. By type of commercial energy, the tertiary sector's demand was satisfied by in 1987 with 68% petroleum fuels, 32% electricity, 10% natural gas. In addition, wood was also used, but data are sketchy. It was estimated that as much natural gas was used as wood. However, in recent years, natural gas consumption has increased rapidly due to the Government's energy pricing policy which favors the use of natural gas.

Tertiary Sector Energy Demand ('87, kTOE)

Subsector	Gas	LPG	Kerosene	Diesel/Fuel oil	Electricity	Total
Hotels	15.5	1.6		33.2	13.2	63.5
Restaurants	1.3	6.3			1.7	9.3
Turkish Baths	0.2		7.6	24.8	0.2	32.9
Public Health	1.5	2.0		11.0	3.5	18.0
Administration	0.2	0.1		4.0	4.3	8.6
Public Lighting					3.8	3.8
Other	0.2	3.1	0.2	16.0	35.3	54.8
Total	18.9	13.1	7.8	89.1	62.0	190.9

Source: ESMAP

a. Hotel Subsector

The hotel subsector is rapidly growing, particularly the one catering to luxury tourists. In 1987 there were 37 four-star hotels and 83 three-star hotels. In 1994, some 50 hotels in these classes with at least 500 beds each are under construction. Three and four-star hotels make up 28% of the total number of hotels, but consumed 68% of the energy demand in this subsector. Intervention in the luxury hotel subsector is likely to be much more cost-effective and expeditious than in the non-luxury hotels.

Electricity is mainly used for lighting and air conditioning, while fuel oil/diesel and natural gas are mainly used for cooking and water heating. The use of natural gas is increasing rapidly, but the gas pipeline is not available in all of Tunisia. The main tourist areas in the South are not connected, and this is not likely to take place soon either. The following table shows an overview of energy use by type of hotel.

Energy Demand Hotel Subsector ('87, kTOE)

Hotel class	****	***	**	others	Total
Number	37	83	87	228	435
Fuel oil/diesel	9.2	10.7	6.7	6.6	33.2
Natural gas	6.3	5.6	1.8	1.7	15.4
Electricity	6.2	5.0	1.4	0.6	13.2
LPG	0.2	0.2	0.5	0.6	1.6
Total	21.9	21.5	10.5	9.5	63.5

Source: ESMAP

b. Other Subsectors

Other tertiary subsectors of interest are the Turkish Baths (Hammams) and sports facilities, specifically those with swimming pools. The Turkish Bath subsector is consuming a considerable amount of energy, but the demand is stagnant and there are not many new baths under construction. Many of the Turkish Baths are located in the middle of towns and villages, completely surrounded by other buildings. In addition to hot water, steam and spaceheating is required as well. Precise energy consumption data are scarce, and the following table presents estimates made by AME in collaboration with ESMAP in 1987, mainly based on the '84 INS census.

Energy Demand Turkish Bath Subsector ('87, kTOE)

Fuel type	kTOE
Diesel	24.8
Wood	17.3
Kerosene	7.6
Natural gas	0.2
Electricity	0.2
Total	50.3

Source: ESMAP

3. Residential Sector

In the residential sector, most energy is consumed for cooking (74%), while space (9%) and water (7%) heating are the next largest energy consuming services requested. The following table shows the services requested, and the quantity on energy needed, in 1984 (no later data available), for all households. In addition, a similar table is given for electrified households only, for 1989.

Energy Consumption by Type of Energy, all Households ('84, kTOE)

Type of Energy	Wood	Charcoal	Natl gas	LPG	Kerosene	Fuel oil/diesel	Electricity	Total
Cooking	378	81	10	125	57			652
Space heating	13	19		2	22		1	78
Water heating	21			20	16	22	8	65
Lighting				2	41		17	59
Appliances							30	30
Total	411	100	10	149	136	22	56	884

Source: ESMAP

Energy Consumption by Type of Energy, Electrified Households ('89, kTOE)

Type of Energy	Wood + Charcoal	Natl gas	LPG	Kerosene	Fuel oil/diesel	Electricity	Total
Cooking	11.7	11.7	202	9.4			234.8
Space heating	31.9	5.2	4.2	41.3	14.6	1.2	98.4
Water heating	1.9	4.9	44.4	16.6		7.5	75.3
Refrigeration						32.3	32.3
Lighting						22.6	22.6
Television						16.5	16.5
Other						3.5	3.5
Total	45.5	21.8	250.6	67.3	14.6	83.6	483.4

Source: ESMAP

Water heating accounts for 7% in the sample of all households, and for 15% in the electrified households sample. Although this is a considerably large energy consumption, it is not the first priority of households which have the means to use energy for other purposes than cooking, space heating, and lighting. About 30% of all households use some sort of water heating equipment - other than a stove with which they cook and also heat water.

B. Demand for Hot Water

The residential sector is by far the largest consumer of hot water, with 62% of the total consumption. Turkish baths are the second largest consumer (21%) followed by hotels (11%). The following table presents the demand for hot water, the energy required, and the associated emissions. Projections show that demand for hot water will more than quadruple for the household sector and the sport facilities, while for the hotels, schools, and health facilities it will more than double or almost triple. Thus, the importance of the residential sector for hot water demand will even increase, and by the year 2010 it will be 80% of the total consumption. The increase in hot water demand for Turkish baths is limited and an increase of only 30% is expected by the year 2010.

Hot Water Demand Aspects (1993)

Consumer	'000 m3 @70C	kTOE	kt CO2
Households	11,942	89.3	296.8
Turkish baths	4,081	42.5	105.8
Hotels	2,089	16.9	47.6
Schools	415	4.1	12.1
Sport facilities	322	4.8	13.3
Army	197	1.9	5.7
Health facilities	111	1.1	3.3
Total	19,157	160.7	484.6

Source: TECSOL ('94)

C. Solar Energy in Tunisia

The solar regime is good in Tunisia with more than 3000 hours of sunshine per year, and an average daily insolation of 4.5 kWh/m2 (in the North) and 5.2 (South) kWh/m2. About 30,000 m2 of solar water heaters collector area is installed: 24,000 m2 for residential water heating, mainly in households replacing electric water heaters (some 7000 systems); 5,000 m2 in some 30 hotels; and 800 m2 is exported to Morocco. One manufacturer of SWH systems exist in Tunisia (SEN). Its capacity is about 5000 m2 per year, but it currently produces only 1000 m2. It has a product line with four different models: with a storage capacity of 200, 250, 300, and 500 liters. Cost of the systems (collector plus balance of system, BOS) range from $ 312 to $430 per m2 of collector area. This price does neither include transport over 25 km, nor installation. Another company which is no longer in business, SIAME, has produced SWHs. Le Rayon Solaire is considering starting the production in Tunisia of SWH and other products.

The Government promoted the use of SWHs by providing tax incentives to end-users and manufacturers: exemption of VAT for imported or locally produced renewable energy equipment; and financial assistance was provided for the purchase by households (initially a 7 year loan with 6% interest, which increased later to 10%), with payments through STEG's electricity billing system.

Although some technical problems with SEN's products have been resolved (corrosion, quality of collector), there still are a few remaining: the electrical backup heater will always keep the temperature of the water at 60 C (thereby decreasing environmental benefits), there is currently no maintenance and after service provided to the SWH systems already in use.

As a result of these problems, sales of SWHs have decreased, and they seem to be bottomed out at about 1000 m2 of collector area per year. Import of SWH is not prohibited, but an import duty exemption does not exist, hampering the imports of SWH and forcing local production to be more in-line with international standards, both in terms of quality and prices.

Annex II: Solar Water Heating Experience in Tunisia

Table of contents:

1. Assessment of existing technology and experience

1.1 Collective systems

There is at present only one tertiary sector SWH (Solar Hot Water) system in the whole of Tunisia: a 420 m2 installation at the "Sultan" hotel in Hammamet. Apart from this, there are some thirty hotels which have individual SWH units installed on bungalows, three hotels that have solar swimming pool heating systems and one hotel using a combination of solar energy (pool heating technology) for pre-heating water which is subsequently upgraded in temperature by an electrically driven heat pump.

The present project does not aim at pool heating (small potential for CO2 saving) nor heat pump systems (replacing low grade solar energy by high grade electricity) and so only the experience of the Sultan hotel is relevant. This means that the experience with collective SWH in Tunisia is limited to a single installation.

Neither has this unique experience been a success. An analysis of the energy consumption figures before and after installation of the solar system showed that a substantial drop in energy consumption occurred in the months immediately after the solar system became operational (august 1988) but the energy saving became gradually less until at the end of 1988 the energy consumption per person/night was on the same level as before installation of the solar system. This situation then continued unchanged until the present day.

From observations on the site it would appear that due to severe scaling in the heat exchangers, only a fraction of the available solar heat is actually put to use. This would normally result in energy saving: however a second heat exchanger, between the back-up boiler and hot water storage, is probably equally badly scaled and gas fired boiler needs to operate longer and on a higher temperature in order to heat the water to the desired temperature. Thus, what little solar gain there still is, it is compensated by a lower than usual boiler efficiency, resulting in about zero net energy saving.

Such a situation, although extreme in this particular case, is typical for SWH systems with integrated back-up facility. Any reduction in solar contribution is automatically compensated by the back-up and because the end result (sufficient hot water) is good, the management is often not aware that the solar system is not operating well and so money is being lost by burning fossil fuel unnecessarily.

To minimize the chances of this to happen, it is important that 1) the installation be adequately metered (energy flux, waterflows, pressures and temperatures) so that changes can be noted, 2) that the operating staff be trained so as to know what to look out for and how to deal with problems and 3) that the management monitors the monthly energy bills.

1.2 Retrofit

The feasibility of retrofitting a SWH system to an existing heating plant depends mainly on the physical possibility to accommodate collector field outside and the extra storage capacity, heat exchangers and plumbing inside the existing building. This usually entails more elaborate plumbing and so tends to raise the installation cost to a higher level than would otherwise be the case for first time installation. The overall difference in investment cost for initial or retrofitting is however is usually low.

For solar systems of less than 300m2, the option of collectors with integrated storage can be particularly attractive for retrofitting because this avoids almost all plumbing and storage facilities in the existing boiler room.

The solar system should in all cases be considered as providing pre-heated water to the normal fuel operated water heating system. As such it does not replace the normal equipment but rather it constitutes an addition. This is all the more so because for hotels in Tunisia, the same fuel fired boilers are also used in winter to provide space heating.

1.3 Solar fraction

The solar fraction or solar coverage is the part of the load on annual base, which is covered by solar energy. As a rule of the thumb system are designed in such a way as to maximize the solar fraction without generating surplus energy at any given time. Generally this means that systems are sized for about 100% solar coverage for the months of maximum insolation (July, august), accepting that in the months of less insolation the back-up boiler will cover the energy deficit. There is however some room for adjusting the north-south angle of the collectors by which the solar energy supply can be reduced in summer compensated by an increase in winter. This "flattening" of the supply curve is often useful where energy demand remains constant throughout the year.

For tourist hotels, which is the main target group for this project, the demand for hot water already resembles the annual solar energy supply curve because the room occupancy rate is much higher in summer than in winter. This means that the overall annual solar fraction may be in the order of 80-90%. For other applications such as hospitals, public bath houses and schools the situation is less good because hospitals and public baths are likely to have a constant demand and schools may be even worse because they often close in the summer months.

There is no experience in Tunisia to substantiate such estimations as there is only a single hotel with solar water heating, which has not been monitored and which only worked for a few months.

1.4 Local manufacture capacity

At present there is only one local producer of SWH systems, which is the parastatal SEN (Serept Energie Nouvelle). This company in fact makes only individual systems and is at present in serious financial difficulties. There is no engineering capacity at the moment to design tailor made collective SWH systems, nor has any experience in this field been generated. Although it was this company that supplied the SWH system at the Sultan hotel, it was at that time in collaboration with ELF (oil company) who provided the know-how. This collaboration has been terminated and a new partner has not yet been found.

SEN produces solar collectors which could be used for collective SWH systems, but comparison of performance figures revealed that the efficiency of their collectors is about 20% less than that of present state of the art collectors on the international market.

If SEN survives the present crisis, a collaboration with a foreign company will be essential in getting access to the know-how required to redesign their individual systems and to design collective systems. Redesign of the individual systems will be necessary to improve cost/performance ratio, increase durability of the storage tank and reduce maintenance requirements.

2. Assessment of ICB procedure for the Gafsa hospital pilot project.

2.1. Procedure

The procedure followed in this case was that of a design, elaborated in detail by a consultant, on base of which suppliers could bid. In fact it is a copy of what is the usual procedure for conventional fuel fired hot water systems. A performance guarantee contract will soon be signed between the supplier, a French consulting firm and the installer with the agreement of the Hospital administration. In this particular example a number of shortcomings in using the same procedure for solar systems have become apparent after scrutinizing the tender documents:

- The adopted luxurious design has led to a high cost, leaving no option for the suppliers to propose more economical concepts.

- There can be no guarantee of overall system performance as it was not the supplier who was responsible for the engineering. Only sub components performance can be guaranteed such as collectors, heat exchangers, pumps etc.

- The basic parameters such as daily hot water requirement, annual profile of daily requirement and daily consumption profile were estimated on base of very few hard facts and so could well have a margin of error in the order of 50%. This means that the total solar system designed on these parameters may be either 50% over or undersized. The effect of this on the economics is considerable, especially in the case of oversizing when surplus heat will be generated.

- The calculations as to the optimal solar fraction (solar energy contribution to the total) were ambivalent, leading to a less than optimal solar fraction chosen.

It was further noted that the minimum collector efficiency specified in the technical specifications was 10% higher than what is presently possibly to obtain. Nevertheless SEN offered their collectors which have 27% lower efficiency than what was required. In view of the foregoing a different tendering procedure should be adopted in which 1) the supplier is free to propose the most cost effective design, 2) the supplier is responsible for the design of his system and should guarantee its overall performance.

Furthermore, given the importance of the parameters, based on which the supplier designs the system, it is very important to establish these parameters with as much accuracy as is practically possible, rather than basing the on (weak) assumptions as was done in this pilot project. The parameters such as hot water requirement should preferably be measured during a number of months so as to be sure at least for some months what the daily requirement is as well as the daily consumption profile.

Careful consideration should also be given to determine the temperature at which the hot water should be made available. Generally 45C is taken as sufficient for bathing and showering whereas for kitchens and laundry 55C is preferred. The intelligent use of thermostatic valves and if feasible the use of separate circulation loops for the different temperature levels, can avoid that all the water is heated to the highest temperature (55C) requirement. This temperature aspect is important because setting unrealistic high temperature results in system oversize and bad economics.

2.2 Technology assessment and suggestions

As stated earlier, the design of the system was already done and the supplier could only offer equipment as was specified. The following observations can be made as to the choice of technology and specifications for the Gafsa project and suggestions as to what is suitable for the Tunisian market:

Hot water storage

The design is such that the full storage capacity is subjected to the mains water pressure. This requires large volume pressure vessels which are relatively expensive (fig1).
A better alternative would be to incorporate the storage volume in the primary solar circuit and transfer the heat to a small back-up reservoir through a heat exchanger (fig.2).
In this design the storage is much cheaper because it is pressureless and at the same time the problem of corrosion and scaling in the main storage is avoided as no fresh water enters the system.

Whether or not a non-pressurized storage can be used depends largely on the daily hot water extraction profile. In case of a non-pressurized storage, the momentary heat demand must be extracted through a heat exchanger which consequently must have a high capacity when a large part of the daily consumption is concentrated in a short time. In a pressurized system the heat is already in the water to be used so it can respond easier to demand peaks. It is clear from this discussion that hard data on the daily hot water consumption profile are of primary importance for the system design and calculations.

Another storage option which has only recently come on the market is the so called integrated storage in which each collector module is combined with a storage volume (fig.3). This makes the system completely modular, avoids most of the normally required plumbing and takes up no space in the boiler room. It has only a variable cost component (contrary to systems with separate storage which have both a fixed and a variable cost component) which makes the cost/m2 insensitive to scale between about 30 and 300 m2. Above 300m2, separate storage often becomes more economical.

Frost protection

For the Gafsa project an anti freeze additive has been provided in the primary (collector) circuit. This option is not the cheapest, there are likely to be difficulties on the long term with the supply of the glycol and there is a danger to health in case through leakage of a heat exchanger, the glycol gets into the consumption water system. Particularly for collective systems it would be a better option to chose a drain-down design. In this option the collector circuit drains down, either by gravity or by a pump, the moment the temperature drops below zero. It should be noted though that frost protection will rarely be needed in Tunisia, particularly not in the area where most of the tourist hotels are located.

Collectors

The type of collectors as to be used for the Gafsa project i.e. flat plate, single glazing and selective coated absorber, is the most suitable.

Heat exchangers

Plate heat exchangers are suitable and most often used because they are easily accessible for cleaning (removing scale deposits) and by virtue of their large heat transfer surface, they provide a high rate of heat transfer at low temperature difference. Another option is tubular spiral heat exchangers, placed inside the storage tanks. They are not so sensitive to scaling as plate exchangers but their accessibility for cleaning is generally less good, particularly when a large units are used. This option only becomes attractive if a modular approach is chosen for the storage. For instance a series of 1m3 tanks, connected in parallel, each tank having its own internal heat exchanger which, because being small, can relatively easily be removed for cleaning. Internal heat exchangers in the tanks (fig.4) reduces the need for circulation pumps from four to two, lowering investment cost and electricity consumption while also simplifying the system.

Initially shell and tube heat exchangers were specified for Gafsa, which would not have been suitable because they are bulky and difficult to clean. This has later been changed to plate exchangers.

Thermal insulation

Only the insulation exposed to the sunlight should be metal covered, to prevent degradation due to ultra violet radiation. The insulation of the pipes, storage tanks and heat exchangers, usually installed inside a building does not require metal covering. For the Gafsa hospital it was specified that all insulation, including the storage tanks, should be metal covered, this unnecessarily increases the cost.

Monitoring equipment

The following meters should be provided as a minimum:

- kWh meter between the cold water inlet and the hot water outlet from the solar storage tank in order to monitor the solar system's effective energy output.
- Water meter in the water intake to the hot water system to measure the hot water consumption.
- Water meter in the collector loop (primary circuit) to check on the circulation.
- Thermometers should be fitted at all entrances and exits of tanks and heat exchangers.
- Pressure gauges should be fitted at all entrances and exits of the heat exchangers in order to check on pressure drops associated with scale build-up.

For the Gafsa project it was not clearly specified which gauges are to be fitted where.

Circulation pumps

The circulation pumps for the primary and secondary circuits need not be necessarily of the twin parallel type as was specified for the Gafsa project. This doubles the cost of the pumps and adds no value to the system. It is advisable though that a spare pump of each type is always kept in stock, particularly for the pump in the loop between the boiler and the back-up storage tank.

Safety

Protection shall standard be provided against overheating, which should at least include a mechanical pressure relief valve as a back-up, even in case some other safety measure such as automatic draining of the collectors has been envisaged.

2.3 Prices

The prices for the SWH system for the Gafsa pilot project included additional steel structures for accommodating the collectors, remote monitoring equipment and anti freeze protection. These costs have been isolated and deducted. The component cost was then adjusted by leaving out the obvious "luxury" items such as double circulation pumps, total insulation metal cladding, excessive system marking etc.

This deduction process resulted in a system cost with some reference value. The total system cost was then broken down into costs which can be considered as "fixed costs" largely independent of system size (within limits) and "variable costs" which are dependent on the collector surface to be installed. For the Gafsa project this analysis resulted in a overall system cost for 240m2 of $ 480/m2, composed of $ 160/m2 of fixed costs and $ 320/m2 of variable costs.

Compared with prices obtained from different sources as to specific system costs in Europe, the cost for the offered system in Tunisia stands out as high, as can be seen from the table below:

Complete, turn-key system costs in US$/m2

Country	Collector Area and Storage System 150m2 A	150m2 B	300m2 A	300m2 B
Greece	280	350	280	280
Holland	-	500	-	300
Tunisia (Gafsa)	-	580	-	450

A: Storage integrated into collector
B: Separate storage system

Although the cost of a solar system, made in a European country, delivered and installed in Tunisia is likely to be higher because of the distance, this increase is likely to be offset by a corresponding decrease in labor cost for installation and a judicious use of locally available equipment such as storage tanks, piping etc.

3 Maintenance and durability

3.1 Durability

A SWH system includes very few moving parts and if well designed will not be much affected by corrosion. The predominant factor determining corrosion and scaling is the water quality. In the case of Tunisia the water generally has a large mineral content causing both scaling and corrosion (chloride). For this reason it is common practice in Tunisia for the conventional collective hot water systems to install a "water softener device" upstream of the system. This works well to reduce scaling and to some extend also corrosion. Provided that the water softener is most of the time operational, it can be assumed that the water entering the solar heating system is of an average quality in terms of scaling and corrosion characteristics. Based on the general experience and observations at the Sultan hotel (solar installation 6 years old and storage tanks 12 years) the following service life estimations for the different sub components of the solar system seem realistic in the Tunisian context:

Collector

- Usually corrosion proof because the shell is made of aluminum, the cover of glass, the absorber of copper and the insulation of a non degradable material. Provided that the same water is constantly recirculated through the absorber, the absorber will not be affected by scale build-up or corrosion. It is generally assumed that good collectors will last at least 20 years and most likely still work well up to 30 years.

Storage tank

- For this item the durability depends very much on the system design (constantly fresh or recirculated water), on the material (stainless steel or carbon steel), wall thickness, coating, water quality etc.

  The lifetime for storage tanks may thus be in a range from a minimum of 5 years for an in-line pressurized carbon steel tank to a maximum of about 30 years for a closed loop non pressurized or stainless steel tank.

Heat exchangers

- Plate heat exchangers, due to their ease of cleaning and the fact that the plates are made of stainless steel have a virtually unlimited service life.

  If spiral tubes inside the tanks are used, they can last up to 25 years if made from (the right type) of stainless steel or not much more than 5-10 years if made from carbon steel.

Circulation pumps

- The pumps can be affected by scaling (depending on which circuit they are in) which affects their lifetime and the motor life is shorter than normal for pumps because of relatively high temperatures in which they need to work. Generally pumps don't last more than 5-8 years.

Valves and plumbing

- Only the part of the plumbing where the water is constantly renewed may be subject to scaling and corrosion, depending on factors such as local temperature, flow velocity, presence of copper containing metals etc. The valves in the system are few and rarely used. It may occur that a valve needs to be dismantled for cleaning (from scaling) but these occasions will be rare.

Electric controls

- The electric controls for the solar system are simple and consist generally of two differential switches, each with two temperature sensors. One for activating the circulation pump in the primary loop and the other for the secondary loop. Manual overriding switches should be provided plus motor protection relays for over current. The service life of these components tends to vary widely but as an average about 10 years may be assumed.

3.2 Maintenance

The maintenance work on a collective SWH system is little and most of it can be carried out by the existing maintenance staff of the facility (hotel or other), provided proper instruction has been given. The danger with these installations is that because of the presence of a back-up boiler, one may not be aware of a reduced solar system performance. It is only by regularly monitoring the solar energy flux (through the kWh meter) that performance reduction can be noted. This is really where the maintenance begins.

Once a performance reduction has been observed, the cause of it must be diagnosed before it can be corrected. Proper instruction of the maintenance staff by the equipment supplier is essential here, including maintenance manuals and fault finding charts.

The normal maintenance work to be expected will be:

- Cleaning of the collector.
  The collector glass covers will generally need washing twice a month or after dust storms. For this purpose water taps must be located conveniently in the collector field, to attach a garden hose.

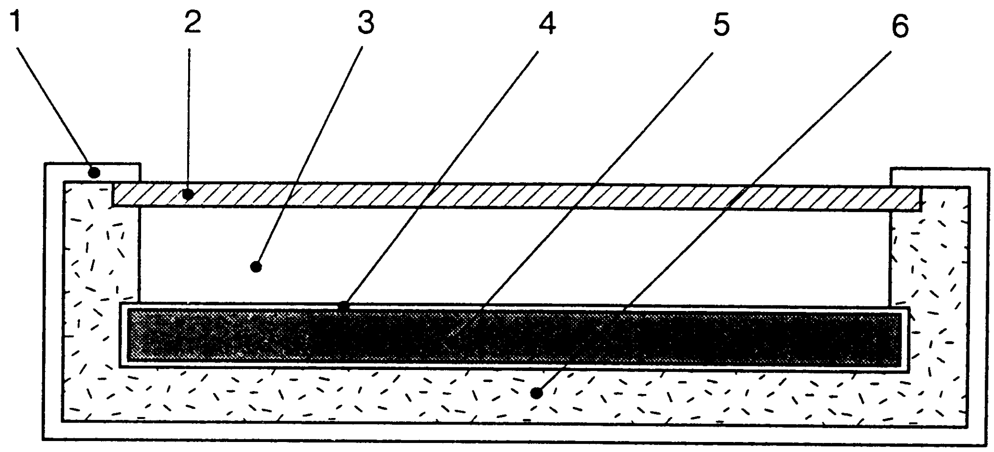
- Cleaning of the heat exchangers
  When the pressure gauges fitted on the inlets and outlets of the heat exchangers show an increase in pressure drop (because of scaling) dismantling and cleaning is indicated. The scaling will normally only occur on "fresh" water side, not the side where the same water is being recirculated. The frequency of this operation depends very much on the mineral content of the water (after softening). In extreme cases it may be necessary every three months and in the best of cases at least once a year. When cleaning a plate heat exchanger it is often advisable to replace the gaskets which assure the sealing between the plates and it is essential to keep a stock of gaskets on site.

  When spiral tube heat exchangers are used, performance reduction can only be observed by monitoring the in and outlet temperatures because the scaling takes place on the outside of the tube and so does not affect the flow resistance. Removal and cleaning is easy provided the units are small enough to be handled by two persons. The manhole gaskets will generally need to be replaced after a cleaning operation.

- Cleaning the circulation pumps
  The parts of the pumps which are in contact with the water such as the impeller and inside of the pump casing are also likely to be effected by scale deposits. This results in a decreased flowrate which can be observed from the installed watermeters. The frequency of de-scaling the pumps is usually not high, not more than once every 2 years. In order to reduce the chance of scaling in the pumps it is important that they be fitted in the coolest part of the circuit. It is advisable to keep one pump of each type in stock on site in case complete replacement or cleaning is necessary.

- Cleaning pipework and valves
  At some points in the system scale deposits may lead to reduced circulation flow rates and must then be cleaned. This is not likely to happen more than once in 5 years if the system has been well designed i.e. the pipe diameters should be sufficiently oversized to be able to accommodate some scaling without affecting the system performance.

- Flow distribution in collector field
  The average flow through each collector should be in the order of 50 l/min.m2, with variations of 10% under or above still acceptable. If however the flowrate in certain parts of the collector field becomes too low, the efficiency will be affected. A collector field is generally composed of a series of parallel banks with common inlet and outlet pipes. Each inlet to a bank should be provided with a throttle valve and pressure gauge (downstream of the valve) and the adjustment of the throttle valves should be such that the pressure gauges all show the same reading. This is part of the starting-up procedure but changes may take place over time and periodic adjustment may be necessary.



1 Box
2 Transparent cover
3 Air gap
4 Absorber
5 Circulating water
6 Thermal insulation

Fig. 1 Solar collector of the "greenhouse" type

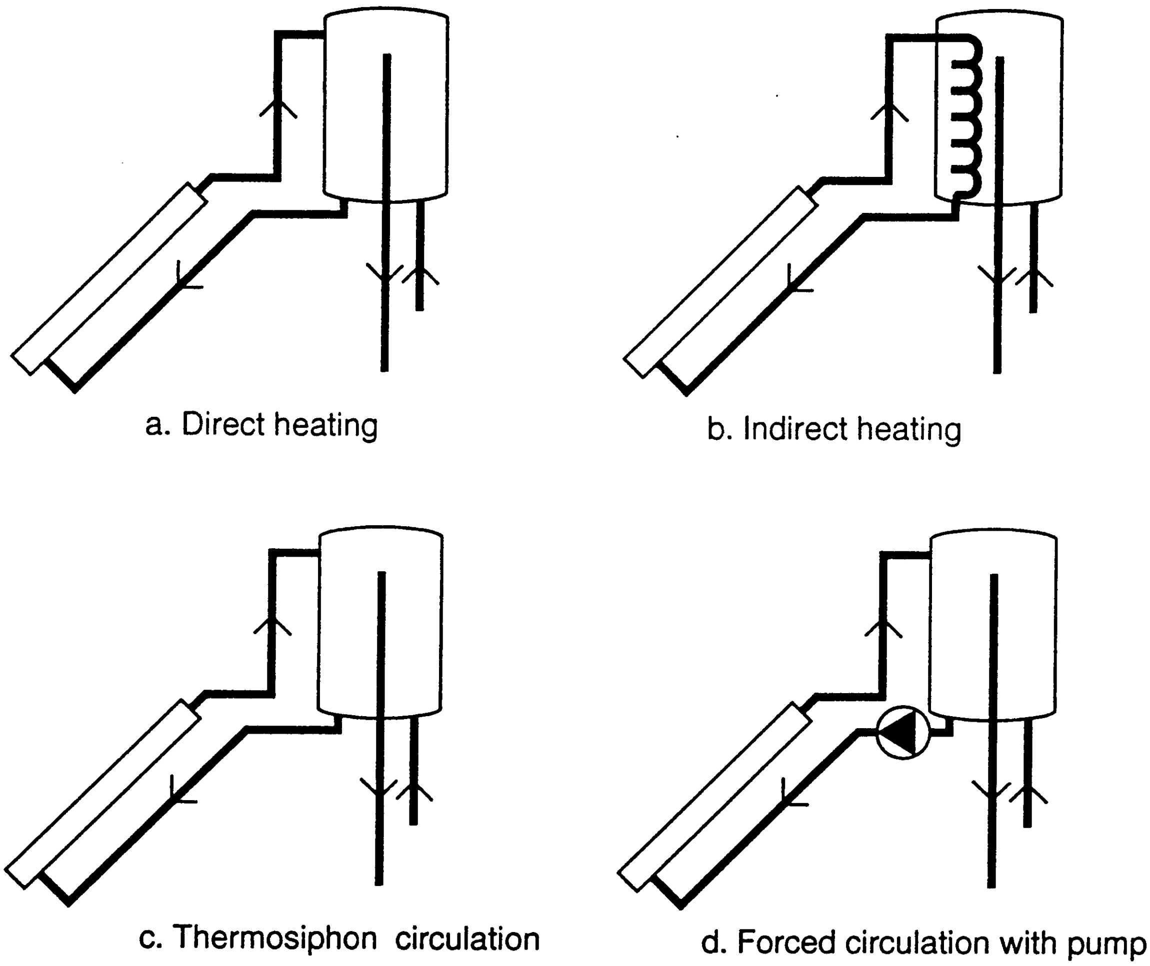
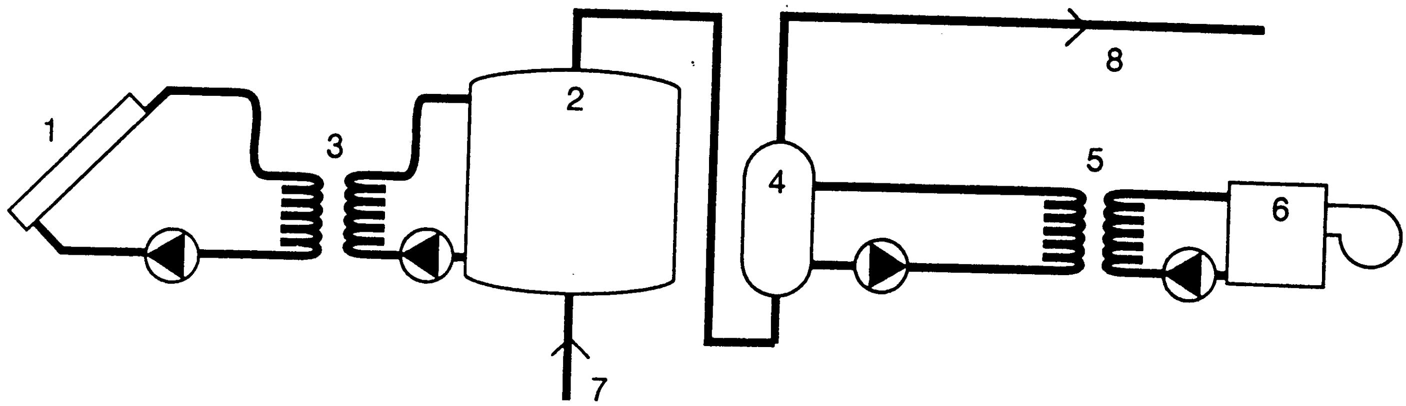
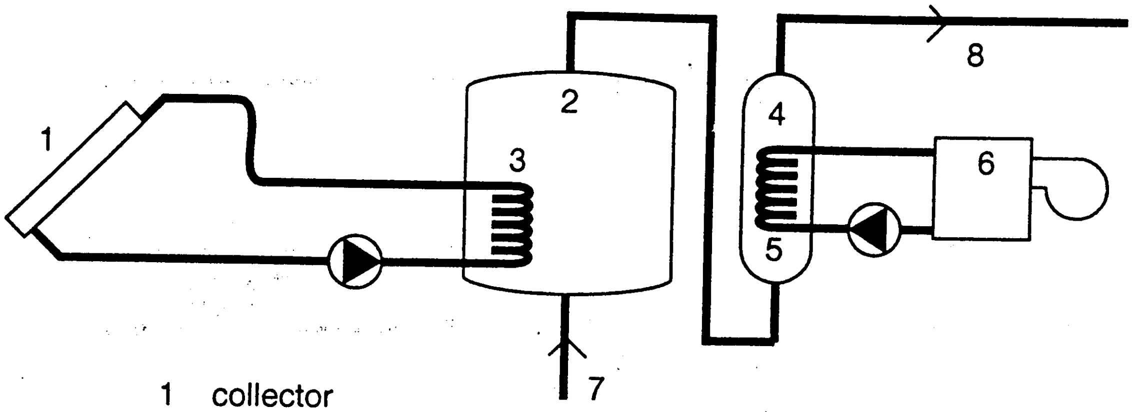


Fig. 2 Basic configurations of residential SHW systems



1 collector
2 main storage
3 heat exchanger
4 back-up storage
5 heat exchanger
6 back-up boiler
7 cold water entrance
8 hot water to consumption
circulation pump

Fig. 4 Full pressure main storage



1 collector
2 main storage
3 heat exchanger
4 back-up storage
5 heat exchanger
6 back-up boiler
7 cold water entrance
8 hot water to consumption
⯈ circulation pump

Fig. 5 Integrated storage and heat exchangers

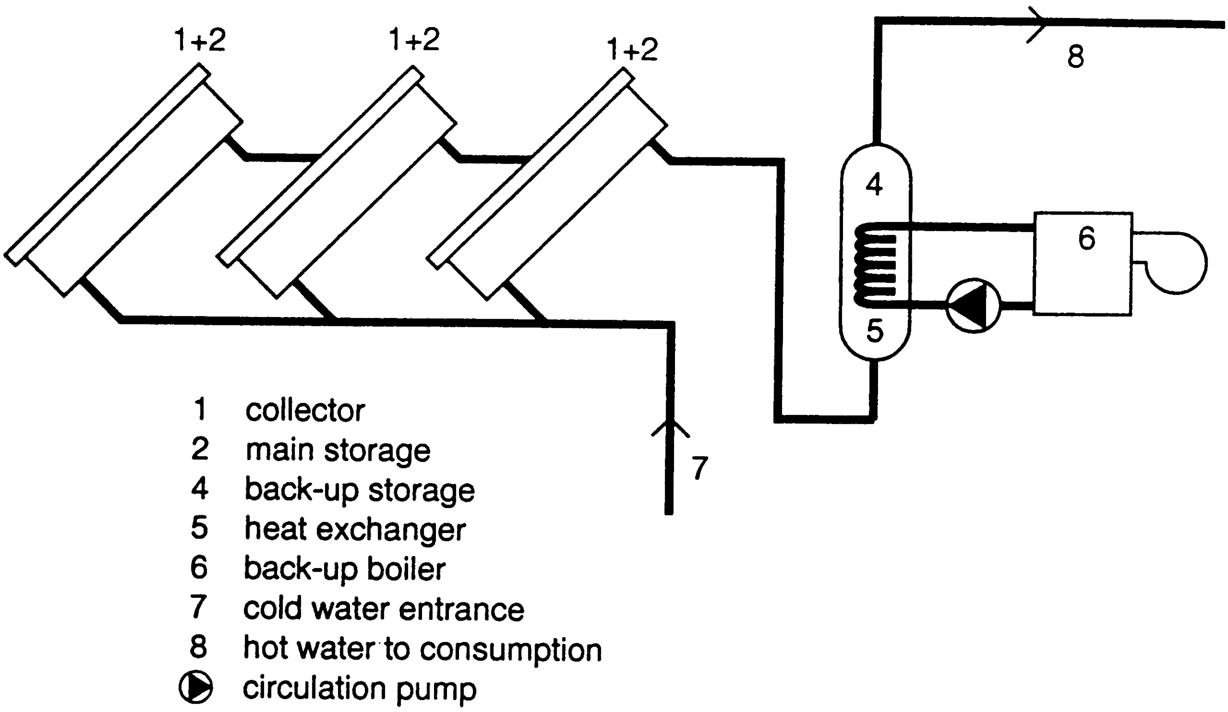


Fig. 6 Integrated collector main storage

Annex III: Economic Analysis of Solar Water Heating Project

Methodology

The analysis is carried out in two steps: first, the appropriate level of subsidy is determined for typical potential users in each subsector, taking into account the specific details for that subsector and user; second, the results of this are applied to a market penetration model which relates disbursement profiles to avoided emissions for each subsector to estimate overall environmental costs to the project.

To identify the maximum level of subsidy for a particular end-user in certain subsector, one determines the total avoided emissions over the lifetime of the equipment, multiplied by the maximum acceptable cost per ton of avoided CO2 emissions, and divided by the cost of the equipment. As a result of the subsidy, the payback time on the investment shortens, and the internal rate of return increases. Cost elements taken into account in this analysis are the investment costs, operational, repair and maintenance costs, and fuel costs. Benefits are avoided fuel costs. Environmental costs are not considered in this analysis. Potential clients of the SWH project, mainly owners of tertiary sector establishments, are basically interested in technical and financial performance of waterheaters, and take their decision based on these criteria.

Whether the benefits resulting from the subsidy are sufficient to convince potential users to invest in SWH rather than in conventional boiler technology, can only be determined in practice. In theory, payback times are roughly 3 - 5 years (with an IRR of about 20%), and this normally should be sufficient for private sector participation. Discussions were held with owners of tertiary sector establishments indicated that indeed they might be interested in investing in SWH technology. This is confirmed in practice as several owners requested from AME more information on the future SWH program.

The level of subsidies are used as input in the market penetration model, and the cost of the subsidy represent the costs of the project. Benefits of the project are the avoided emissions. The outcome of the model is the overall cost of avoided emissions for all subsectors combined which should not exceed the maximum indicated by GEF guidelines.

Assumptions

As mentioned in the main text of the report, SWH cannot compete with natural gas boilers. this is for two reasons: first, the price of natural gas is very low (and thus financial benefits of avoided fuel consumption are low too), and second, environmental benefits are also low because natural gas is a relatively clean fuel.

Electricity would be the best fuel to replace but there are only few tertiary sector establishments using electricity for water heating. This is often done, however, in the residential sector, but intervention in this sector in the framework of the project is limited to real estate developers only.

The second best fuel to replace is fueloil, which is the main form of energy in the tertiary sector. This is changing though, and particularly natural gas consumption is increasing rapidly. However, many parts of the country will not be connected to the natural gas network for the foreseeable future. The project will target its potential clients in these regions.

Three scenarios for the costs of a SWH system in Tunisia are considered, one which is based on the recent ICB for the Gafsa hospital procured under the CR 2735-TUN Energy Conservation Project (160 m2 of collector area; in many ways this has been a luxury project, and does not really reflect the state of the art; see also Annex II for a description), the second is based on average international market prices at this time, and the third is based on the lowest cost system found at this time, assuming that in the future this system can be installed in Tunisia for the same costs. Fixed and variable costs components for SWH systems of size 100 m2 to 500 m2 were considered. Fixed costs amount to DT 23,500 (imported) and DT 15,000 (local) for each system, while variable costs amount to DT 160 per m2 (imported) and DT 160 per m2 (local). These costs include taxes (for imports), parts, and labor (See Table 1).

Based on the reports from consultants engaged by AME for this project (TECSOL, MRS Entreprises), certain assumptions were made on the distribution of total energy use for water heating in each tertiary subsector, as well as economic growth and the maximum potential clients for retrofitting existing water heating installations as well as new clients (See Table 4) for each subsector.

The solar coverage is the total annual contribution of the SWH system towards the energy needs for water heating in a year. This is a simplification, as there are certain peak times: diurnally corresponding to (for hotels) taking a shower after waking up and at the end of the afternoon, and monthly, corresponding to the tourist season. A sensitivity analysis will need to be carried out by the potential user in collaboration with the supplier of the equipment to determine the optimum configuration. In general, one looks at the energy demand during the peak month for insolation, and determines the size of the SWH system accordingly.

Results of Analysis

Tables 1, 2, and 3 show the baseline case for a medium-sized hotel for the installation of a 350 m2 SWH system. The "without case" (when the hotel owner invests in a fueloil boiler) is compared to the "with case" (SWH installation) for the three scenarios. A GEF subsidy of 25% will result in a financial internal rate of return (IRR) of about 20% to 28%, with a corresponding payback time of 3 to 5 years. The costs of avoided emissions range from DT 7.6 to DT 9.5 per ton, mainly depending on the cost of the SWH installation. It is assumed that SWH costs will lie between the "International Market" and the "Future Market" scenario.

In current terms the costs of avoided emissions are expected to decrease from their present levels: cost of equipment is likely to become available for lower costs due to improvements of sector efficiencies as a result of international competitive bidding and increase volume of sales. This also implies that future avoided emissions will be available at lower cost as a result of the GEF project, or, that it is not very important when initially the costs of avoided emissions are somewhat higher than the GEF criteria.

Tables 4, 5 , and 6 show the market penetration scenario broken down by subsectors: hotels, Turkish Baths, schools, health institutions, sport facilities, residential buildings. Table 4 shows the assumptions for each subsector. Solar coverage and Cost of SWH system are derived parameters: solar coverage depends on the end-users' energy demand, the collector area, and the insolation at the site; the cost of the SWH system mainly depends on the size of the system (due to scale economies), solar coverage, and site specifications. As an example, it will in general be more expensive to install an equally sized SWH system in a Turkish Bath than in a hotel. Turkish Baths are usually built in the center of town, fully enclosed by other buildings, and often with a dome or otherwise round roof making installation of panels difficult. In addition, for steam generation and spaceheating, high temperature water and air are necessary that cannot easily be generated by SWHs.

Avoided emissions amount to 293 ktons of CO2 over the lifetime of the equipment that is installed through the GEF grant. The avoided cost of emissions amount to DT 8.1 per ton. However, one can argue that, because the project's objectives are to trigger sustainable development of the SWH market, it is appropriate to take into account the results of that development. Over a period of 20 years, avoided emissions amount to 972 ktons, resulting in an avoided cost of DT 2.5 per ton of CO2. Taking into account all avoided emissions resulting from the investments done during a 20 year period (starting from the onset of the GEF project), avoided emissions would amount to 2.5 million tons, resulting in avoided costs of about DT 1 per ton of CO2.

Discussion

The project is a worthwhile one indeed, with a large potential for global benefits. Unit costs of avoided emissions as the immediate result of the project may be a bit high compared to other Global Warming projects. However, if one takes into account the results of the market penetration at a larger scale as the result of the GEF project, unit costs drop quickly to very attractive levels. Given the level of participation of the private sector and of tapping into existing schemes and procedures, the likelihood of succeeding is relatively high. In addition, the introduction of performance guarantees will help establish positive client reactions and help avoid the earlier mistakes with SHW in Tunisia.

Table 1: Baseline Model Solar Water Heating - assumptions (hotel subsector; using fueloil)

Hot water demand	20	m3/day
Water temperature		
cold	20	Celcius
hot	60	Celcius
Efficiency of boiler		
fuel oil	50%	
natural gas	70%	
electricity	80%	
Collector area to be installed	350	m2
Solar coverage	74%	
Energy contribution collector	720	kWh/m2-yr
"	2.592	GJ/m2-yr
Depreciation rate	10%	
Annual energy price increase	1%	
Investment bonus SWH (government)	5%	of total investments
GEF subsidy SWH	25%	of total investments

Fuel Characteristics	DT/toe	DT/MJ	kg CO2/MJ
fuel oil	301	0.007	0.089
natural gas	131	0.003	0.058
LPG	244	0.006	0.067
electricity	701	0.017	0.209

Price of SWH (100 - 500 m2): DT	tax (VAT) applied	Tunisia actual	International market	Future market
fixed costs - imported (DT)	10%	23,500	19,153	15,275
fixed costs local (DT)	0%	15,000	12,225	9,750
variable costs - imported (DT/m2)	10%	160	130	104
variable costs - local (DT/m2)	0%	160	130	104
Total costs/m2 installed (DT/m2)		430	350	280
Operational costs (DT/year)				
spare parts (as % of fixed costs)	0.36%	138	112	90
labor (as % of variable costs)	0.26%	286	233	186

Conventional boiler

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Costs (DT/year)																					
Engineering study	1,200																				
Investments	12,500																				
Installation	6,667																				
Spare parts		188	188	188	188	188	188	188	188	188	188	188	188	188	188	188	188	188	188	188	188
Labor (maintenance, repairs)		133	133	133	133	133	133	133	133	133	133	133	133	133	133	133	133	133	133	133	133
Energy costs		17,495	17,670	17,846	18,025	18,205	18,387	18,571	18,757	18,944	19,134	19,325	19,518	19,713	19,911	20,110	20,311	20,514	20,719	20,926	21,135
Total costs	20,367	17,816	17,991	18,168	18,346	18,527	18,709	18,893	19,078	19,266	19,455	19,647	19,840	20,035	20,232	20,431	20,632	20,836	21,041	21,248	21,457
Hot water production (m3/year)		7,300	7,300	7,300	7,300	7,300	7,300	7,300	7,300	7,300	7,300	7,300	7,300	7,300	7,300	7,300	7,300	7,300	7,300	7,300	7,300
Conventional energy consumption (GJ/year)		2,441	2,441	2,441	2,441	2,441	2,441	2,441	2,441	2,441	2,441	2,441	2,441	2,441	2,441	2,441	2,441	2,441	2,441	2,441	2,441
CO_2 Emissions (t)		217	217	217	217	217	217	217	217	217	217	217	217	217	217	217	217	217	217	217	217

NPV costs	165,668 DT
NPV hot water use	56,499 m3
CO_2 emissions	4,340 t
LRMC hot water	2.93 DT/m3

SWH system with backup

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Costs (DT/year)																					
Investments SWH system	97,825																				
Investment bonus	-4,891																				
GEF subsidy	-24,456																				
Spare parts		350	350	350	350	350	350	350	350	350	350	350	350	350	350	350	350	350	350	350	350
Labor (maintenance, repairs)		250	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250
Energy costs		4,491	4,536	4,582	4,628	4,674	4,721	4,768	4,815	4,864	4,912	4,961	5,011	5,061	5,112	5,163	5,214	5,267	5,319	5,372	5,426
Total costs	68,478	5,091	5,136	5,182	5,228	5,274	5,321	5,368	5,415	5,464	5,512	5,561	5,611	5,661	5,712	5,763	5,814	5,867	5,919	5,972	6,026
Hot water production (m3/year)		7300	7300	7300	7300	7300	7300	7300	7300	7300	7300	7300	7300	7300	7300	7300	7300	7300	7300	7300	7300
Conventional energy consumption (GJ/year)		626.72	626.72	626.72	626.72	626.72	626.72	626.72	626.72	626.72	626.72	626.72	626.72	626.72	626.72	626.72	626.72	626.72	626.72	626.72	626.72
CO_2 Emissions (t)		55.7	55.7	55.7	55.7	55.7	55.7	55.7	55.7	55.7	55.7	55.7	55.7	55.7	55.7	55.7	55.7	55.7	55.7	55.7	55.7
Avoided emissions (t CO_2/yr)	0	161.3	161.3	161.3	161.3	161.3	161.3	161.3	161.3	161.3	161.3	161.3	161.3	161.3	161.3	161.3	161.3	161.3	161.3	161.3	161.3
Net savings (DT/year)	-48,111	12,725	12,855	12,986	13,119	13,253	13,388	13,525	13,663	13,802	13,943	14,085	14,229	14,374	14,521	14,669	14,818	14,969	15,121	15,275	15,431

NPV costs	104,036 DT
NPV hot water use	56,499 m3
CO_2 emissions	1,114 t
LRMC hot water	1.84 DT/m3
Avoided emissions/m2-yr	0.46 t/m2-yr
Total avoided emissions	3,226 t
Internal rate of Return	27.2%
Payback time (years)	3
Cost of avoided emissions (DT/t)	7.6

Table 3: Sensitivity Analysis (hotel subsector, using fueloil)

Internal rate of return as function of GEF subsidy & cost per m2

	cost per m2 (installed)		
GEF Subsidy	$430	$350	$280
15%	12%	17%	23%
20%	14%	18%	25%
25%	15%	20%	28%
30%	17%	22%	31%

Payback time as function of GEF subsidy & cost per m2

	cost per m2 (installed)		
GEF Subsidy	$430	$350	$280
15%	7	5	4
20%	6	5	4
25%	6	5	3
30%	5	4	3

Cost per avoided t of CO2 as function of GEF subsidy & cost per m2

	cost per m2 (installed)		
GEF Subsidy	$430	$350	$280
15%	7.0	5.7	4.5
20%	9.3	7.6	6.1
25%	11.7	9.5	7.6
30%	14.0	11.4	9.1

POTENTIAL MARKET FOR SOLAR WATER HEATING IN TUNISIA

Table 4: Assumptions

	Hotel Sector	Turkish Bath	Education Sector	Health Sector	Sport Sector	Residential Sector
Potential market						
- existing installations	20%	10%	15%	20%	15%	25%
- new installations	50%		65%	80%	50%	40%
Penetration in 20 years	50%	30%	75%	80%	50%	50%
Annual growth of sector	10.0%	4.0%	7.0%	7.0%	8.0%	9.0%
Solar coverage	74%	55%	66%	55%	83%	55%
Reduction SWH prices	2%	2%	2%	2%	2%	2%
Investment premium	5%	5%	0%	0%	5%	5%
Base GEF subsidy	35%	35%	35%	35%	35%	35%
Depreciation rate	10%	10%	10%	10%	10%	10%
Cost of SWH system (DT/m2)	350	522	440	365	435	418

Table 5: Summary Results

Potential solar market (m2) (1995 - 2015)	255,513	100%
Hotels	153,091	60%
Turkish Bath	3,649	1%
Education	49,633	19%
Health	5,255	2%
Sport	5,162	2%
Residential	38,723	15%
Accumulated GEF subsidy ('000 DT$)	6,557	
NPV GEF subsidy (('000 DT$)	4,032	
NPV investments generated ('000 DT$)		
for the same period	16,128	
over a 20 year period	30,158	
Avoided emissions (t)		
as immediate result of GEF subsidy	636,458	
over 20 year period	971,866	
over the life of SWH installed 1995 - 2015	2,506,108	
Cost of avoided emissions (DT/t)		
as immediate result of GEF subsidy	**7.5**	
over 20 year period	**4.3**	
over the life of SWH installed 1995 - 2015	**1.8**	
Ratio investments/GEF subsidy		
for the same period	2.4	
over a 20 year period	7.4	

(*) emissions over the lifetime of the equipment

Table 6: Market penetration scenario

	1,996	2,000	2,005	2,010	2,015
Potential solar market (m2)	5,004	7,034	10,808	16,676	25,826
Hotels	2,673	3,913	6,303	10,150	16,347
Turkish Bath	123	143	174	212	258
Education	1,211	1,587	2,226	3,122	4,379
Health	128	168	236	331	464
Sport	113	153	225	331	487
Residential	757	1,068	1,644	2,529	3,892
Cumulative market (m2)	5,004	29,873	75,703	146,310	255,513
Potential CO2 reduction (t)	2,453	14,647	37,124	71,755	125,305
Investments generated ('000 DT)	2,232	2,879	3,930	5,308	7,060

Annex IV - Monitoring Program

All SWH systems subsidized by the GEF program will be monitored. Data to be collected include information on the quantity of CO2 emission avoided and the operation (technically and economically) of the SWH systems for the different target groups in Tunisian. These data are also important for the design of future SWH systems to be installed. For this purpose the following monitoring program is proposed:

Data recording

Basic data will be recorded by the user on a daily basis. AME will collect and summarize these data and prepare monthly performance reports (by SWH system installed with GEF assistance). For the first year of operation, it is recommended that AME collects data sheets from users on a monthly basis, but over time -- and if the system performs according to the specifications -- this may be reduced to four to six times a year. Annual progress reports for the project as a whole will be prepared as well, outlining technical and economic performance by subsector as well as obtained environmental benefits.

Data to be measured	How to collect
Energy supplied by the solar system.	- Calorimeter between the solar storage tank and the back-up storage tank. The cold water inlet will be taken as temperature reference. - Cumulative registration.
Energy supplied by the back-up boiler.	- Calorimeter between the outlet of the back-up storage and the entrance of the distribution system. The preheated water from the solar storage tank will be taken as temperature reference. - Cumulative registration.
Hot water consumption.	- A watermeter to be placed in the cold water feeding line to the solar storage tank. - Cumulative registration.
Fuel consumption.	- Fuel (oil or gas) meter, measuring total fuel consumption including space heating, cooking and hot water back-up. - This meter is normally present and need not be part of the solar installation.
Hot water temperature.	- To be taken at the entrance to the distribution system. - This cannot be cumulative and so must either incorporate a writing device or an electronic data storage facility.

Maintenance.	- Maintenance contracts must be signed between the beneficiary and the installer; AME can perform a direct supervision of one or two pilot projects; for all others, supervision will be performed on the basis of reports regularly transmitted to AME.

Processing and Reporting

Quarterly Summary Installation Performance report

Produced by: AME
Distribution: AME and owner solar system.
Contents:

- Supplied solar energy
- Quarterly solar fraction
- Quarterly and average daily hot water consumption plus specific water consumption per person, client, tourist or whatever applicable.
- Average hot water temperature
- Interventions on the system, nature and costs.
- Observations

Economic Performance report

Frequency: Annual
Produced by: Owner solar system
Distribution: AME and owner.
Contents:

- Obtained energy saving
- Obtained financial saving
- Cost of maintenance
- Observations on the functioning of the system.
- Comparison between projected and real figures as to savings and hot water consumption.

Annual Project Progress report

Frequency: Annual
Produced by: AME
Distribution: AME, owner solar system.

Technical part

- All the monthly values, their totals and annual average.
- Comparison between projected and real values.
- Description of interventions, maintenance or other.

Economic part

- Obtained energy savings
- Comparison between projected and real savings
- Observations

Environmental part

- Amount of CO2 emission avoided (tons)
- Real cost per ton of CO2 non emitted.

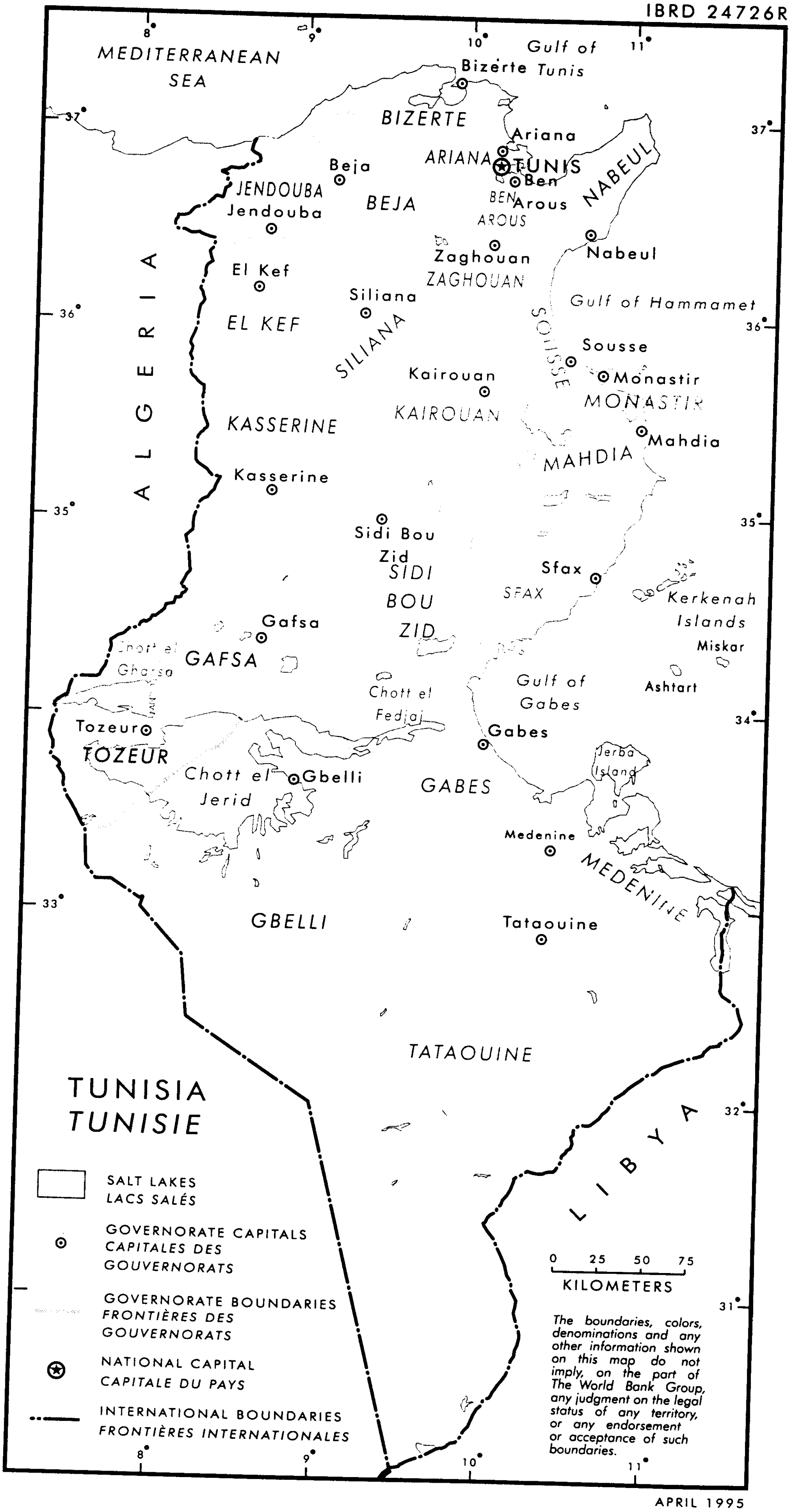
Cost estimate of monitoring equipment per installation
(Cost in US $)

	Quant. required		Cost/piece	Total	
Calorimeter	2	*	1250	2.500	
Watermeter	2		850	1.700	Fuel/gas
meter	1		550	550	
Temperature recorder	1	*	2000	2.000	
Thermometers	8		20	160	
Differential pressure gauges	4		70	280	

		Total in US $		7.190	

*) It should be noted that out of the above listed instruments only the temperature recorder and the second calorimeter are supplementary to the gauges and meters which should normally be provided in a collective SWH system. The extra cost for GEF monitoring would consequently amount to $ 1250 + $2000 is $ 3.250 per SWH installation.

MAP SECTION



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Nabeul
Zaghouan
ZAGHOUAN
El Kef
EL KEF
Siliana
SILIANA
Gulf of Hammamet
SOUSSE
Sousse
Monastir
MONASTIR
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Mahdia
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Kasserine
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SFAX
Kerkenah Islands
Gafsa
GAFSA
Chott el Gharsa
Miskar
Ashtart
Gulf of Gabes
Chott el Fedjaj
Tozeur
TOZEUR
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Jerba Island
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APRIL 1995