PROJECT FINAL REPORT

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1. List of beneficiaries and main contacts

1.1 List of beneficiaries

Beneficiary Number *	Beneficiary name	Beneficiary short name	Country	Date enter project**	Date exit project**
1 (coordinator)	Observatoire Méditerranéen de l'Energie	OME	France	month 1	month 24
2	Centre de Développement des Energies Renouvelables	CDER	Morocco	month 1	month 24
3	Deutsches Zentrum für Luft-und Raumfart e.V.	DLR	Germany	month 1	month 24
4	Electricité de France	EDF	France	month 1	month 24
5	BENEFICIARY HAS WITHDRAWN	-	-	-	-
6	Kernenergien - the solar power company	KERNENERGIEN	Germany	month 1	month 24
7	Mekorot Water Company Ltd	MEKOROT	Israel	month 1	month 24
8	National Energy Research Center	NERC	Jordan	month 1	month 24
9	New and Renewable Energy Development and Utilization Authority	NREA	Egypt	month 1	month 24
10	Office National de l'Eau Potable	ONEP	Morocco	month 1	month 24
11	Palestinian Energy and Environment Research Center	PEC	PNA	month 1	month 24
12	BENEFICIARY HAS WITHDRAWN	-	-	-	-
13	Techint Compagnia Tecnica Internazionale S.p.A	TECHINT	Italy	month 1	month 24
14	INVEN Engineering GmbH	INVEN	Germany	month 1	month 24
15	The Cyprus Institute - Energy, Environment and Water Research Center	EEWRC	Cyprus	Month 6	Month 24

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2. Summary of results and main conclusions

The MED-CSD project has aimed to carry out feasibility studies of combined concentrated solar power and desalination plants in five countries (Cyprus, Egypt, Italian Islands, Morocco, and Palestinian National Authority). In the first place, a complete review of technology options has been elaborated and a comprehensive methodology to carry out the feasibility study has been developed. In parallel, an assessment of water demand and deficit as well as of electricity demand has been conducted for each country. Derived from these assessments, markets potential scenarios for CSP desalination and generation have been performed. Finally, the socio-economic impact of a broad dissemination of the CSP water desalination has been carried out.

The project's results give information to decision makers for the establishment of a favourable framework for the deployment of concentrated solar power and desalination plants through the techno-economic analyses of potential projects conducted. The main results and conclusions of the feasibility studies are synthesized in the Action Plan (Deliverable 4.2) of the project. This Action Plan contains also recommendations for a large scale deployment of the MED-CSD concept.

Finally, a high level final conference took place in Rabat, Morocco, on 18th and 19th May 2010. It was attended by high level representatives such as the Minister of Energy and Mines of Morocco, the Deputy Head of Delegation of the EU in Rabat, the General Director of ONEP/ONE, the President of MASEN (Moroccan Agency for Solar Energy, in charge of the Moroccan Solar Plan) and many others (the list of participants is available upon request, more than 120 participants). The event was also widely covered by the media (TV, radio and press).

It is important to underline that a workshop was organized jointly with ONEP at the occasion of the final conference, and aimed to give participants both the basics of CSP and Desalination technologies (and on-going projects) and an overview of renewable energy in the Southern and Eastern Mediterranean region. This initiative was not scheduled within the MED-CSD Project, but upon request of ONEP, partners of the consortium agreed that such event is important and would also bring added value and visibility to the project and its outcomes.

The MED-CSD project results reinforce the past results of recent studies as AQUA-CSP, (MED-CSP and others), that is to say a sustainable solution to the threatening water crisis in the Mediterranean region, and describe a way to achieve a balanced, affordable and secure water supply structure for the next generation.

2.1 Work Package 1: Technology review and selection of CSP and desalination configurations adapted for application in the Southern and Eastern Mediterranean region

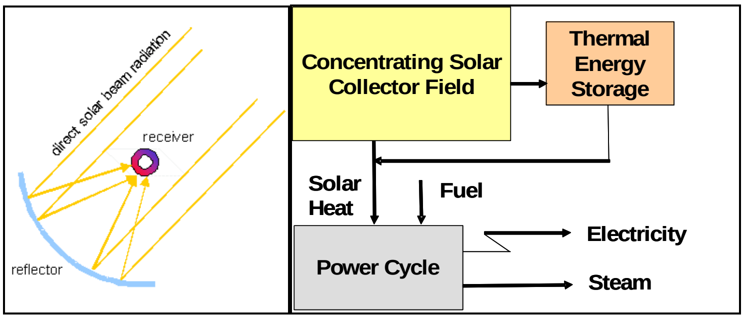
This work package aimed at reviewing the best technology options (CSP and desalination) and at selecting the most appropriate configurations for application in the South Mediterranean region.

CSP Technology

Principle of Concentrating Solar Power

Concentrating solar thermal power plants have the capability for thermal energy storage and alternative hybrid operation with fossil or bio-fuels, allowing them to provide firm power capacity on demand. The core element is a field of large mirrors reflecting the captured sun rays to a small receiver element, thus concentrating the solar radiation intensity by 80 to several 100 times and producing high temperature heat at several 100 to over 1,000 °C. This heat can be either used directly in a thermal power cycle based on steam turbines, gas turbines or Stirling engines, or stored in molten salt, concrete or phase-change material to be delivered later to the power cycle for night-time operation.

Figure 1: Principle of a concentrating solar collector (left) and of a concentrating solar thermal power station for co-generation of electricity and process steam (right)



Source: DLR

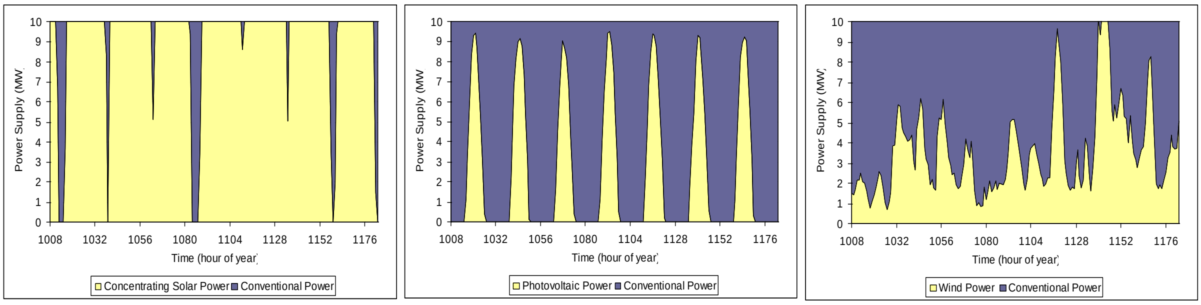
From the point of view of a grid operator, CSP behaves just like any conventional fuel fired power station, but with less or no fuel consumption, thus being an important factor for grid stability and control in a future electricity supply system based mainly on renewable energy sources. CSP plants can be designed from 5 MW to several 100 MW of capacity. Another major advantage of CSP power stations is the fact that the steam turbines used for power generation provide an excellent spinning reserve, which is very important for short time compensation of any failures or outages within the electricity grid. Moreover, the flexible design of CSP plants allows them to operate in all load segments from base load and intermediate load to peaking load services, just as required by grid operators.

Firm capacity

The advantage of CSP for providing constant base load capacity for seawater desalination can be appreciated in Figure 2 for a time-series modelling of one week of operation of equivalent wind, PV and CSP systems with 10 MW installed power capacity each at Hurghada, Egypt: while wind and photovoltaic power systems deliver fluctuating power and either allow only for intermitting solar operation or require considerable conventional backup, a concentrating solar power plant can deliver stable and constant power capacity, due to its thermal energy storage capability and to the possibility of hybrid operation with fuel.

To cover a constant load or to follow a changing load by wind or PV electricity would additionally require the electricity grid and conventional plants for external backup. In our example the renewable share provided by CSP is about 90 %, that of PV is 25 % and that of wind power is about 35-40 %. Depending on varying conditions at different locations, these numbers can be also considered as typical for the average annual renewable share of such systems. As a consequence, CSP plants can save more fossil fuel and replace more conventional power capacity compared to other renewable energy sources like PV and wind power, especially if applied for desalination services.

Figure 2: Power supplied by 10 MW CSP-plant with 16 hour storage (A), a 10 MW PV (B) and 10 MW Wind (C) and conventional backup power from the grid needed to provide constant 10 MW base load supply.



A B C

Source: DLR

CSP technologies

From the point of view of the solar power technology, four main technologies are available.

- **Central receiver systems:** using a large field of two-axis tracking mirrors (heliostats) that reflect the sunlight to a central receiver on top of a tower, where the concentrated solar energy is converted to high temperature heat. The typical optical concentration factor ranges from 200 to 1000, and plant sizes of 5 to 150 MW are feasible;

- **Parabolic trough:** normally designed to track the sun along one axis, pre-dominantly north-south. To generate electricity, a fluid flowing through the absorber tube – usually synthetic oil or water/steam – transfers the solar heat to a conventional steam turbine power cycle. Concentrating the sunlight by about 70 - 100 times, typical operating temperatures are in the range of 350 to 550 °C;

- **Linear Fresnel:** based on large arrays of modular Fresnel reflectors which direct the sunlight to a stationary receiver several meters high. This receiver contains a steel absorber tube and a so-called second stage reflector which re-directs the rays which did not directly hit the absorber. In the absorber tube, the concentrated sunlight is converting water to superheated steam with temperatures up to 450 °C driving a turbine to produce electricity;

- **Parabolic dish:** Using a mirror array formed into the shape of a dish, the solar dish focuses the sun's rays onto a receiver. The receiver transmits the energy to an engine, typically a kinematic Stirling engine that generates electric power. Because of the high concentration ratios achievable with parabolic dishes and the small size of the receiver, solar dishes are efficient at collecting solar energy at very high temperatures;

Desalination Technology

Potable water can be produced from saline water by two main processes, distillation or separation through membranes (see table 1).The driving energy for both processes can be either electrical power or thermal energy. Thermal desalination use heat sources as the driving force. These heat sources can be hot water or steam from a turbine. Therefore thermal desalination is ideal for co-generation with power plants. Electrical power is only necessary for parasitic internal power consumption such as pumps etc.

Table 1: Overview of desalination technologies

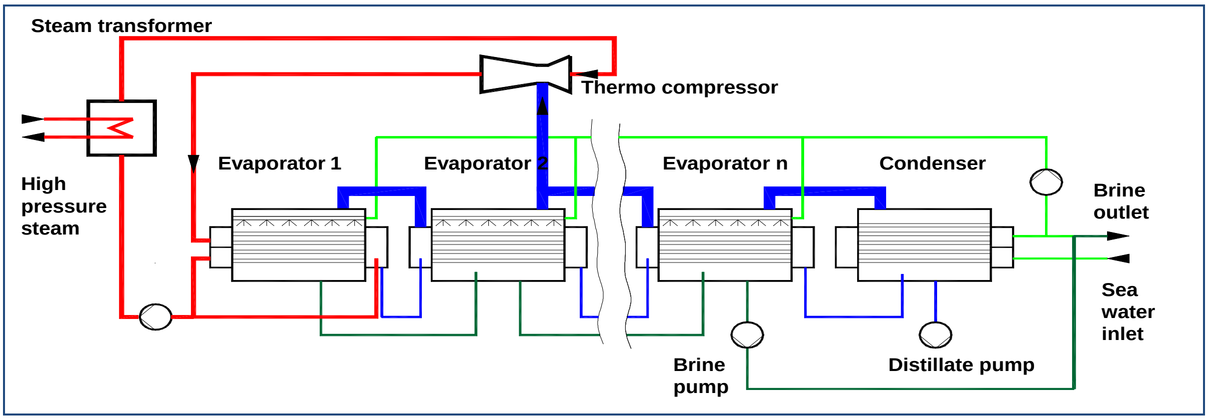
Process / Driving force	Evaporation	Membrane
Thermal Energy	Multi Stage Flash (MSF) Multi Effect Distillation (MED) Solar Stills Multi Effect Humidification (MEH)	Vacuum Membrane Distillation (VMemD)
Electrical Energy	Mechanical Vapour Compression (MVC)	Electro Dialysis (ED) Reverse Osmosis (RO)

Source: INVEN

Evaporation Processes

Basically the state of the art thermal processes comprise the so-called MSF and the MED processes. The MSF has been the workhorse of the large plants due to their robustness. MED is a more recent technology gaining increasing market shares with much lower power consumption for pumps and requiring less heat exchange surface. The MED process itself operates with a maximum brine temperature of only 70 °C. Heat at higher temperature can be used through a thermal vapour compressor. It should be noted that the highest thermal efficiency of a steam turbine plant is only achieved by coupling the MED right to the back of the turbine. Newer developments have shown significant potential of cost saving for example by replacing copper alloys by aluminium, stainless steel or polymers.

Figure 3: Overview of desalination technologies



Source: INVEN

New Developments

The Membrane Distillation Systems also fall into this category. The membrane serves to separate liquid and vapour phase. Thermodynamically the Vacuum Membrane MED is a pure MED process while the spiral-wound systems can be treated as MSF process, having a lower potential for energy saving. Due to the small path length of the steam in the system, the systems are very compact. Completely pre-fabricated single stage and multi stage evaporator modules can be manufactured. Finally, the Humidification system relies on an air stream with natural or forced convection which is carrying the vapour form the evaporation surface to the condensation system. The transport kinetics is a limiting factor for larger units. To date few units are under field test and several companies are promoting the system for smaller sizes (< 50 m^3/ day).

Reverse Osmosis

Since their introduction in the late 1950's, reverse osmosis, nano-filtration, ultra-filtration and micro-filtration have been increasingly used in the field of water treatment. From the early development by Sourirujan and Loeb on the spiral wound cellulose acetate membrane and the invention of capillary technology, has improved performance, reliability and lower operating cost, making membranes the preferred technology for desalination of seawater, brackish water and waste water in many places with moderate salinity world wide. In the last decade RO seawater desalination has gone through a significant transformation. Currently most of newly implemented seawater desalination plants use RO technology. System of 300,000 m^3/day and recently even larger, have been build and are in operation in many parts of the world. Desalted water cost decreased from 2.0 \$/m^3 to 0.5 \$/m^3 and worldwide capacity is continuously increased.

Table 2: Comparison of characteristics of the main desalination technologies

	MED	MSF	MED-TVC	MVC	RO
Raw water qualtity	not critical	not critical	not critical	not critical	very specific pre-treatment
Filter mesh	3 mm	3 mm	3 mm	3 mm	< 50 µm
Distillate quality (ppm TDS)	1-10 pmm	1-10 pmm	1-10 pmm	1-10 pmm	1stage: 300 ppm 2stage: 10-50 ppm
Heat consumption	60-100 kWh/t @ 70°C	60–100 kWh/t @ 120°C	50-100 kWh/t @ 150°C	—	—
Power consumption	< 0,5 kWh/t	3-4 kWh/t	<0,6 kWh/t	8-10 kWh/t	3 – 6 kWh / t
Maintenance cost	low	low	low	low	medium

Source: INVEN

Integration of CSP and desalination technology

The purpose of the MED-CSD comparison is to select the most appropriate thermal or mechanical desalination method for the combination with CSP, and to find a combination that could be representative for large scale dissemination.

MED is more efficient than MSF in terms of primary energy and electricity consumption and has a lower cost. Moreover, the operating temperature of MED is lower, thus requiring steam at lower pressure if connected for combined generation to a steam cycle power plant. Thus, the combination of CSP with MED will be more effective than a combination of CSP and MSF desalination. Comparing the mechanical driven desalination options, reverse osmosis has a lower electricity consumption and cost per unit product water than the mechanical vapour compression method.

The much lower primary energy consumption of RO and the slightly lower cost compared to MED suggests that RO might be the preferred desalination technology anyway. However, if MED is coupled to a power plant, it replaces the cost of the condensation unit of the steam cycle and partially uses waste heat from power generation for the desalination process. In this case, not all the primary energy used must be accounted for the desalination process, but only the portion that is equivalent to a reduction of the amount of electricity generated in the plant when compared to conventional cooling at lower temperature, and of course the direct power consumption of the MED process.

Processes combining thermal and mechanical desalination may lead to more efficient future desalination systems /MEDRC 2001/. However for simplicity, only separated processes have been used for our comparison. Within this study the MED and RO processes will be considered as reference technologies for thermal and for mechanical desalination processes, respectively.

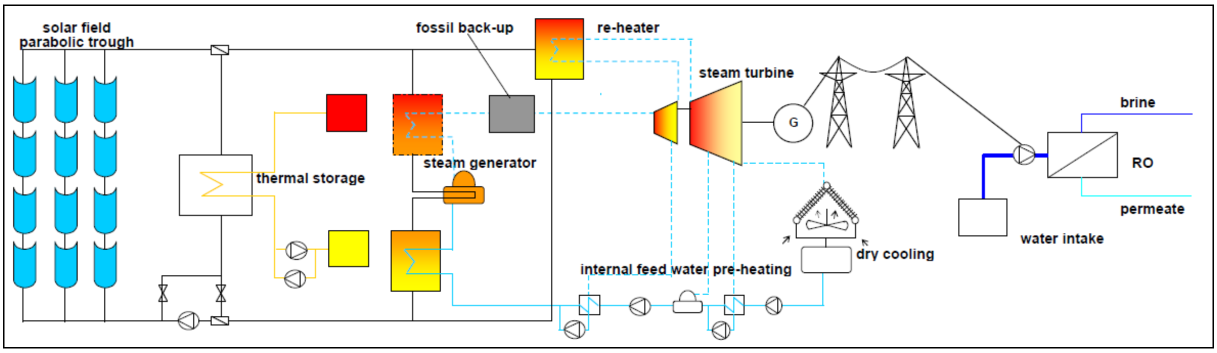
In principle, all CSP technologies can be used for the generation of electricity and heat and are suited to be combined with mechanical as well as with thermal desalination systems. The scope of pre-selection within this study is to find a CSP-technology that can be used as reference with respect to performance, cost and integration with seawater desalination in order to develop a long-term market scenario for CSP/desalination in general based on that technology.

At present, the maturity of point concentrating systems is not as high as that of line concentrating systems. In spite of first demonstration projects of central receivers in Europe in the 1970ies, the only commercial CSP plants today are line concentrating parabolic trough systems. It is still uncertain whether central receivers will be able to compete with line concentrating systems in the lower temperature range up to 550 °C for steam generation. Up to now, line concentrating systems have had clear advantages due to lower cost, less material demand, simpler construction and higher efficiency, and there is still no evidence of a future change of that paradigm.

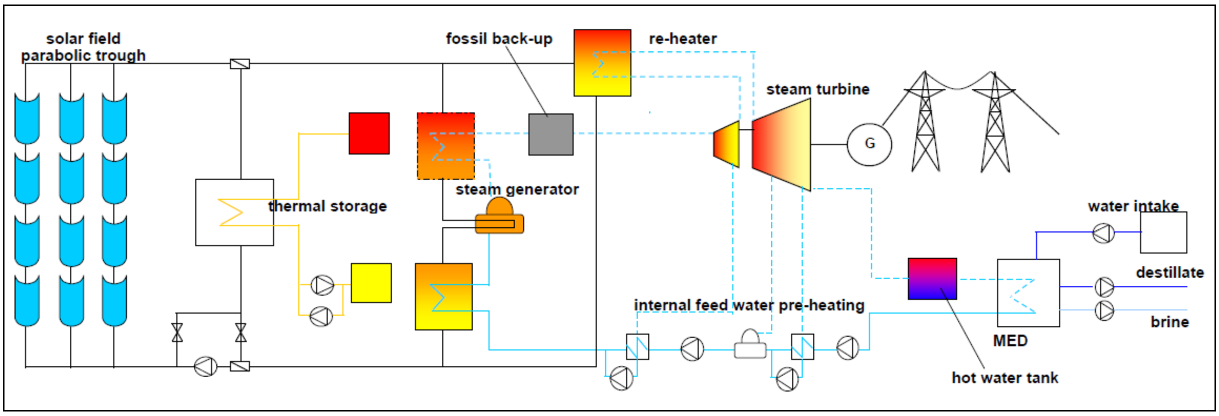
As the main scope of the study was to assess the potential of large scale desalination units with CSP for the major centres of demand in MENA, parabolic dish systems can be excluded as well, as they only operate in the kilowatt range. However, they could be applied for decentralised, remote desalination as will be described in an addendum.

Thus, there were basically two options of combining CSP with seawater desalination that has been investigated within the MED-CSD project:

- Reverse Osmosis Powered by Electricity from a CSP Plant (CSP/RO)



- Multi-Effect Desalination Using Heat & Power from a CSP Plant (CSP/MED)



2.2 Work Package 2: Feasibility Studies of hybrid CSP water desalination plants in the Mediterranean region

Several methodologies and model were developed by the MED-CSD partners

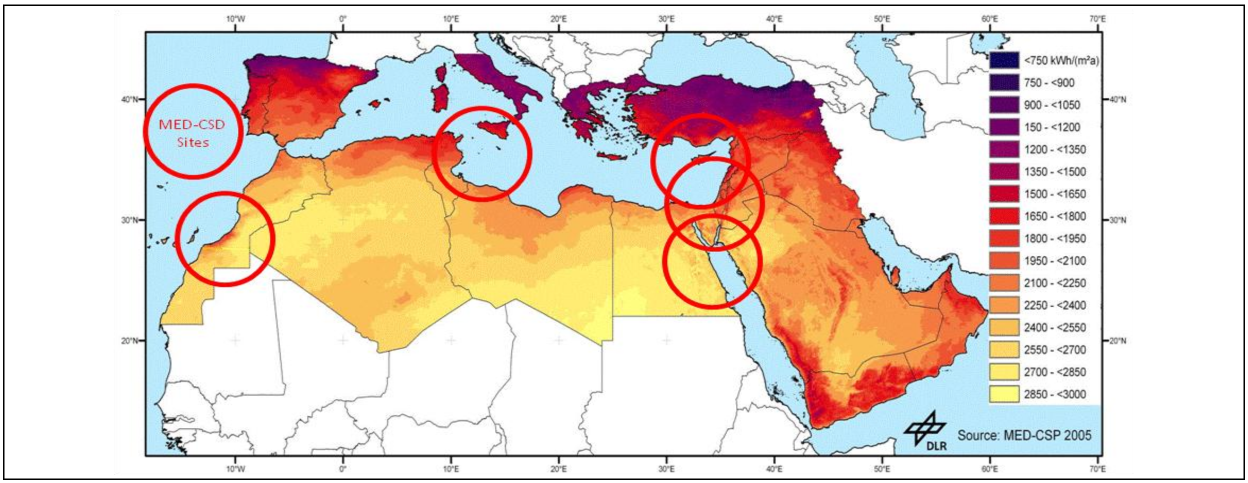
- A Methodology for characterisation of needs for electricity generation and water desalination was created by INVEN and DLR.
- A Methodology for economic and financial analysis and Business Plan was created by EDF and discussed by OME, DLR, KERN and TECHINT.
- After a detailed investigation for performance analysis and a power plant simulation model on the open simulation platform in INSEL was developed by KERN and DLR. None of the commercial programs was able to fulfil the requirement of the project.

First preliminary calculations with simplified program show the variety of configurations and the scope of technical and economical applications. Two major reference designs were selected and are in the implementation process of the performance and economical/financial computer codes and feasibility studies:

- A system based on oil-cooled parabolic trough collectors providing superheated steam for power stations with steam turbine of the ANDASOL type with integrated thermal energy storage (either molten salt or concrete) for approximately 7-8 full load operating hours continuously providing electricity for Reverse Osmosis seawater desalination and feeding peak electricity (surplus not needed for desalination) to the grid.

A system based on direct steam generating linear Fresnel collectors providing saturated steam for a power station with steam turbine in combined generation for a thermal Multi-Effect Distillation plant. The plant uses a concrete storage to store high temperature heat for part load power generation and low temperature heat for the continuous desalination process. The final results for the Italian study indicate the sustainability of the project, even with limited application opportunities, in principle due to the lack of available areas in the minor islands. Solar radiation map of Cyprus, Italian islands, Morocco, Egypt and Palestine were generated and DNI time series were generated by DLR. A pre-selection of sites and characterisation of needs for electricity generation and water desalination all well as a detailed analysis of site data was provided and presented by the national partners.

Figure 4: Direct Normal Insolation (DNI) of the MENA-Region and selected MED-CSD sites



Based on results and local data input a plant design and calculation have been concluded. Various configurations of integrated power and water plants were modelled with INSEL and calculated with several solar models on an hourly–based input. The performance results werde discussed with the national partners. After that the financial model run provided economical results in terms of investment return and payback period. The results were presented at the final conference in Rabat, Morocco.

The first conclusion is that without incentives like grants and/or specific feed-in-tariffs for electricity and water, none of the proposed project is financially profitable at the end of the operation period, from an investor's point of view. However in Italy, where important and accurate feed-in-tariffs are assumed in the model, just a small grant is still required. It means that few adjustments in the input parameters could lead the project to breakeven without any grant.

A second conclusion from this study is that, considering the assumptions which have been taken into account, the more profitable technologies are consistently:

- Linear Fresnel Mirrors as for the solar field technology. On the 72 different studied configurations, the average price of installed capacity is about 5.83 €/We for Linear Fresnel Mirrors, while the average price for Parabolic Trough is 5.95 €/We.

- Reverse Osmosis as for the desalination technology. On the 72 different studied configurations, only considering the CAPEX for desalination, RO desalination has a lower initial investment cost than MED. However this initial investment cost do not include the maintenance cost over the years, especially the replacement cost for the RO modules about every 5 years.

It must be noted that a direct comparison of cost for the desalination unit alone is misleading as the MED unit replaces the heat rejection section of the power plant (cooling tower) as well as expensive condensing stages of the steam turbine. On the other hand, a regular replacement of membranes for RO must also be considered in addition to the initial investment.

The same applies to the solar collectors and the impact on plant design and performance. A major drawback of linear Fresnel is the lack of mature units for the production of superheated steam. Other than parabolic trough collectors the linear Fresnel will lead to very significant savings in the steam turbine and steam cycle as well as storage.

Linear Fresnel Mirrors and Reverse Osmosis technologies lead to lower CAPEX, but Reverse Osmosis technology also allows decreasing significantly the annual fuel consumption

(OPEX). Nevertheless, it has to be noticed that the Linear Fresnel Mirrors technology is not as mature as the Parabolic Trough, and is consequently much more risky from an investor's point of view. Effectively in 2009, more than 611 MWe of Parabolic Trough systems are currently under operation in the world, while only 4 pilot plants (<=5 MWe each) of Linear Fresnel Mirrors are installed worldwide.

In the purpose of making each project profitable, the leverage tools available are to add grants, to benefit from important feed-in-tariff for water and electricity (public volunteer policies or private contracts) or to negotiate from bankers and investors a lower cost of capital. Palestine, Egypt and Morocco are actually more likely to benefit from a grant and/or a debt with an attractive interest rate than European countries (Cyprus, Italy) which have yet attractive feed-in-tariffs. As regard to equity rate of return, the more risky is the country, the higher is the rate. In developing areas like Egypt or Palestine, it is actually difficult to make the project profitable, mainly because of high values of equity return (from 15 % to 20 % in the model assumptions). At last, it is also interesting to increase the share of debt among the total capital required because its cost is cheaper than the cost of equity (leverage effect). But the actual financial crisis in the world and namely in Europe doesn't make the banks well-disposed to take risks.

2.3 Work Package 3: Assessment of the techno-economic potential of CSP for electricity and desalination in MPCs

This work package aimed at carrying out:

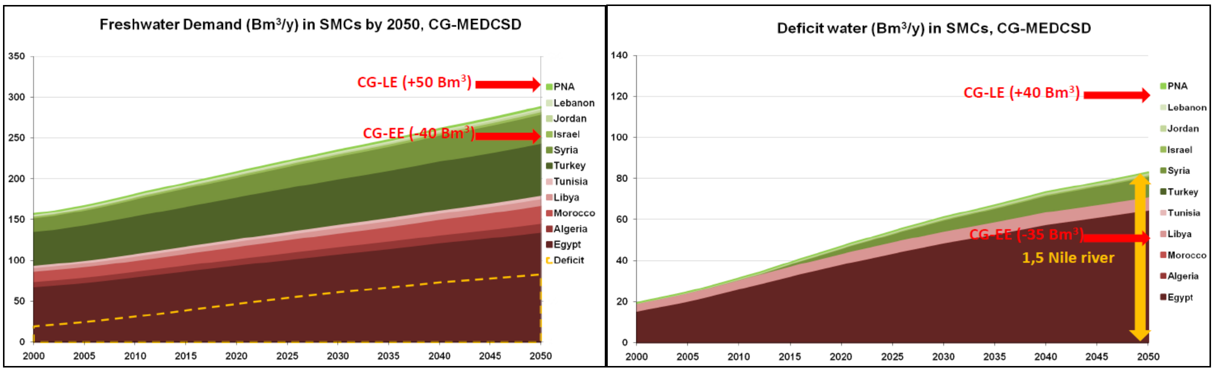
- long-term scenarios for both freshwater demand and deficit
- long-term scenarios for electricity demand
- long-term scenarios of a possible CSP market shares for water and electricity
- socio-economic impact assessment of broad dissemination of the CSP water desalination

Long term scenarios for fresh water demand and deficit

The analysis is based on population growth, economic development, possible efficiency enhancement and a methodology described in the Deliverable 3.1 (D3.1)

The Mediterranean water demand equals today to about 170 Bm^3/y of which 60% in South West Mediterranean Countries. According to MED-CSD scenarios' results, the water demand is expected to grow to 290 Bm^3/y by 2050, that is to say an increase of 70%. Depending on the assumption on measures taken in favour (or not) of a better management in water distribution and use this amount could decrease (increase) of about 40 Bm^3/y (50 Bm^3/y).

Figure 5: water demand and water deficit by 2050 in Mediterranean region



Source: OME

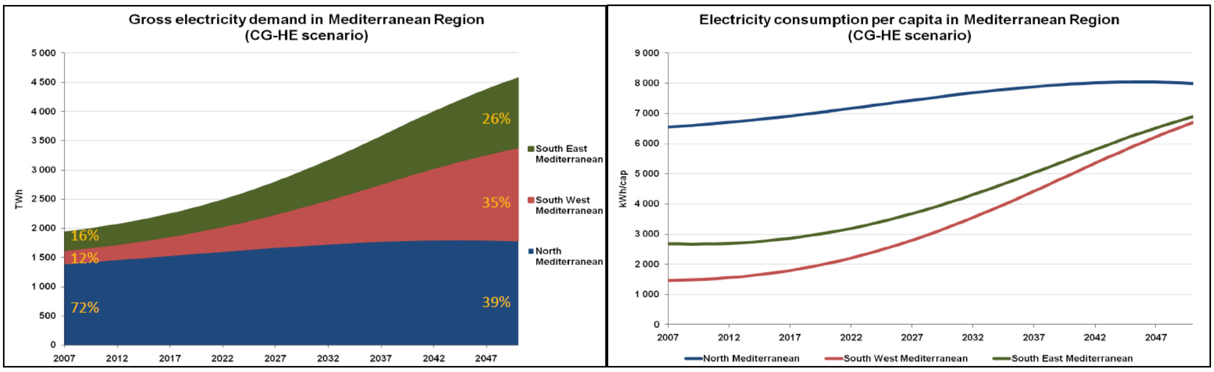
The South Mediterranean region water deficit today equals about 30 billion cubic meters. It is expected to be about 80 billion cubic meters in 2050, equivalent to one Nile and half, representing 30% of the overall demand in Mediterranean region. It could be expected to be reduced of 35 Bm^3/y (increased of about 40 Bm^3/y) respect to the efficiency assumptions. Egypt is by far the most affected countries. It is expected in 2030 that the Egyptian water deficit will equal to one Nile per year, while its population will have increased to 105 million people that time.

Long term scenarios for electricity demand

The analysis is based on population growth, economic development, possible efficiency enhancement and a methodology described in the Deliverable 3.1 (D3.1).

The growth of population and the economic growth will lead to a high increase of energy demand in the Mediterranean region. Indeed, nowadays South Mediterranean region electricity consumption represents 30% of the whole region with 536 TWh/y, while North Mediterranean countries represent 70% (1,400 TWh/y) of the region. According MED-CSD scenarios, which consider several assumptions on efficiency gains and economic growth, it is expected that South Mediterranean region electric consumption will represent between 55% and 60% of the whole region.

Figure 6: Electricity demand in Mediterranean region by 2050



Source: OME

In terms of per capita consumption, according to our assumptions ("Closing the Gap", such as the relative distance between the 2006 average of per capita GDP in North Mediterranean region and the respective countries are reduced by 50% in 2050), it is expected that North Mediterranean per capita consumption will be stabilised around 8000 kWh/cap/y while South Mediterranean per capita consumptions will follow the same trend reaching 7000 kWh/cap/y by 2050. A longer analysis would certainly have shown a stabilisation during the next decades after 2050 of the per capita consumption for South Mediterranean Countries due to the decoupling between GDP and Electricity growths.

In order to respond to the both high increase of water and electricity demands, South Mediterranean Countries will require large amounts of low cost energy for electricity consumption but also for seawater desalination, accompanied by enhanced water and electricity infrastructures and optimal water management.

Long-term scenarios of a possible CSP market shares for water and electricity

The MED-CSD scenarios for water and electricity show that a sustainable future supply is possible in all regions that were analysed within the study. The important role of solar energy for sustainable supply is obvious especially in those countries with highest water stress. This is little surprising, as solar energy is one of the most important drivers for water scarcity.

Water scarcity can in the long run only be solved by desalination, but desalination requires a lot of energy. The logic behind using solar energy to solve the problem is rather imperative.

In all cases enough renewable energy sources are available to cover even a quickly growing demand. However, it is not only important to produce the required amounts of energy, it is more important to produce power at the right time and at the right place, on demand. Therefore, balancing power either for peaking demand or base load from Concentrating Solar Power Stations plays a crucial role within the energy mix of southern countries with abundant solar energy sources.

Table 3 shows the large potential of renewable energy available in the 5 partner countries, which is 10 times larger than the present world electricity consumption of 18,000 TWh/y. It also shows that if following our scenario until 2050 most of the existing resources of wind power, geothermal energy, biomass from waste, hydropower and wave/tidal power will be used almost up to their limits. Only solar energy for PV and CSP has much larger potentials than will ever be used in the region.

Table 3: Renewable energy potential and share used until 2050 in the 5 partner countries according to the MED-CSD market scenarios

MED-CSP Partners	**Potential**	**Used Share**	**Used Share**
Mor, Ita, Cyp, Egy, Pal	**TWh/y**	**TWh/y**	**%**
Wind Power	195	186	95,6%
Photovoltaics	91145	204	0,2%
Geothermal	55	52	94,8%
Biomass	78	74	94,8%
CSP Plants	90193	758	0,8%
Wave / Tidal	3	2	75,0%
Hydropower	94	93	99,4%
Total	181763	1371	0,8%

Source: OME

It is clear that the shift to renewable energy must start now, not as a disruption with the conventional, fossil fuel based system, but as a smooth transient from the present to a more sustainable future. CSP plants for power and water, being potentially hybrid solar/fuel systems themselves, can be a key element for such a smooth transition.

Socio-economic impact assessment of broad dissemination of the CSP water desalination

The goal of the Impact Assessment Study is to underline the potential positive and negative impacts that the adoption of the proposed CSD solution for power generation and water production should have in the Mediterranean Partner Countries.

The analysis is carried on starting from the plant design and results performed for each feasibility study in the WP2.

The techno-economical data obtained in the WP2 feasibility study are the basis to evaluate the consequential impacts in a qualitative and quantitative way, comparing the CSD plant solution with the conventional one used up today.

In such a way a direct comparison between the two theoretical plants provides specific elements of evaluation for a single plant.

The potential demand and market application, as highlighted in the Demand and Market assessment report (deliverables D3.1 and D3.2), will allow to extrapolate the data concerning a single plant and to draft some conclusion relevant to the whole Country scenario.

The main results can be summarised as follows.

The **cost stability** factor is strongly influenced by the kind of reference fuel actually used in the Country. Low cost fuels, like coal, present a big gap to be covered in order to make the CSD solution competitive.

This situation is emphasised by the high hybridization fraction adopted for the CSD plant design, roughly 30 to 40%, required by the continuous operation of the desalination plant. In this way the CSD plant don't realise the stability of production cost, due to the independence from fossil fuel, and the operating cost reduction, after the debt repayment period.

As a result, the CSD plant is competitive vs. the conventional one in Cyprus and Palestine (high cost of actual reference fuel), in Egypt (high irradiation and lower hybridization), but not competitive in Morocco (cheap reference fuel) and Italy-islands (too high investment cost due to small scale plant). This result doesn't take care of future cost increasing for the conventional plants, like emission cost and fuel price increasing over expectations.

In any way a solution of a CSD plant with limited recourse to the back-up fuel (low hybridization, extended energy storage, etc.) will improve the cost stability evaluation.

Another important result is the evaluation of the potential use of **local resources**.

The potential use is higher in the Countries with a numerical higher population and with a strong social growth expectation, like Egypt and Morocco. The situation is opposite in the islands, where there is need of everything, like Cyprus and Italy-island, and in Palestine.

A fundamental factor for local industrial production growth will be the effective volume of installed plants that will be realised in the Mediterranean region. High volume will generate the need to de-localise the production or the final assembly of the technological components too, like reflecting panels and receiver tubes, creating wide opportunities for local investments and capital attraction.

An impact that can be considered positive in all the Countries in the **CO2 emission reduction**.

The reference fuel for the conventional plant is an important parameter to determine the gap between the two solutions. The Morocco case (using coal) will generate a 46,86% of reduction @2050, while the Egypt case (using natural gas), even with a high CSP application potential, will generate only a 17,44% of reduction @2050. The Cyprus case (using oil), even with a lower irradiation, i.e. a higher hybridization, generates more CO2 reduction (22,6% @2050) than Egypt.

Also for the evaluation of this impact, as for the cost stability analysis, the use of fossil fuel as back-up of the CSD plant will limit the benefit of CO2 emission reduction. In fact, in the same way, there is no substantial benefit in Italy-island where the CSD plant and the conventional plant use the same fuel (diesel).

The wider **area occupation** is an evident impact for all cases.

The CCGT plant presents a more compact layout respect an ST conventional plant, in particular in presence of large coal yard or oil storage tank system. In this regard the multiple of required area for a CSD plant is in the range from 90 (Morocco – ST coal) to 130 (Egypt – CCGT natural gas).

The scale effect also will penalise the small scale CSD plants, as the value of irradiation, considering that the multiple of required area for the Italy-islands CSD plant rump-up to 230.

Even the gap between the two technologies is huge, the essential parameter to be taken into consideration is the availability of land, that has to be evaluated case by case and that lead to prefer the abundance of desert areas, not usable for other purposes.

In conclusion, the Impact Assessment reveals a good potential for an extensive application of CSD solutions, with positive effects on production cost stability, social growth and improvement, contribution to the CO2 emission reduction.

To maximise the application potential and the benefit values, the following key elements have been highlighted:

- limitation of the plant hybridization, with emphasis to the more advanced technological solutions in terms of efficiency and energy storage;
- simplification of the technical solutions in order to extend as far as possible the use of local resources, with consequential benefit for the investment costs;
- careful selection of suitable areas / regions in order to maximise the available irradiation, with consequential benefit for plant cost/efficiency and recourse to back-up fuel, and to minimize the use of land good for other purposes, like human life or agriculture.

2.4 Work Package 4: Action Plan and dissemination

Action Plan

The Action Plan (D4.2) contains a summary of each feasibility study and recommendations for the large scale development of the MED-CSD concept. Main recommendations are:

- i) Create secure, reliable and attractive market conditions for CSP investment in MPC's
- ii) Reduce the economic risks of CSP projects in the MPC's in order to reduce loan and equity interest rates by offering national and international guarantees on power and water purchase agreements
- iii) Provide adequate long-term tariffs for power and water from CSP to reduce the economic risk and thus the capital cost of CSP investments
- iv) Provide support for regional CSP component production industry to increase local share of supply
- v) Provide long-term tariff and capacity planning schemes for CSP in the MPC's

Final Conference

The final conference took place in Rabat, Morocco, on 18^{th} and 19^{th} May 2010. It was very successful with attendance of high level representatives such as the minister of Energy and mines of Morocco, the Deputy Head of Delegation of the EU in Rabat, the General Director of ONEP/ONE, the President of MASEN (Moroccan Agency for Solar Energy, in charge of the Moroccan Solar Plan) and many others (the list of participants is available upon request, more than 120 participants). The event was also widely covered by the media (TV, radio and press).

The main aims of the final conference were:

- To give a general overview on energy and water contexts in the Mediterranean area and to introduce CSP, Desalination and combined CSP-Desalination plants in this context;
- To present the main results of the MED-CSD project;
- To have an open discussion on the way forward for the development of CSP and desalination development in the Mediterranean Region.

During the first day, the high level opening session was very successful and attended by more than 120 persons. ***HE Minister Benkhadra*** opened the Conference highlighting in particular the important efforts Morocco is devoting to RE and also the important projects for water desalination. She underlined the willingness of Morocco to become a leader country in green economy and also a partner for green electricity exports to Europe.

The first part of the second day was devoted to the presentation by partners of the main results of the project. The first session was dedicated to the “heart” of the project (WP2), i.e the feasibility studies. Then, partners presented the results within the WP3, regarding the electricity and water demand assessment, CSP market supply scenarios and impact assessment achieved within the project.

The third session of the conference *(“How to promote CSP for water desalination in the Mediterranean region?”*) was organized in three round tables and lively discussion after each round table. Three topics were discussed: “Policies and measures”, “National and regional initiatives”, “financing tools and opportunities”.

3. Socio-economic impacts of the project

The MED-CSD results summarised above show that the combined production of electricity and water from solar resources is feasible and economically viable. The Mediterranean region is characterized by a high increase of the demand both in terms of water and electricity. To develop a sustainable means of production of these two essential vectors of development should have real impacts on economic, social and environmental point of view. Indeed, many impacts are expected from a large scale development of such approach, among them:

- Contribution to economic development and security of supply
- Development of employment and poverty reduction
- Contribution to the protection of environment
- Contribution to EU Policies
- Impact on the new European Neighbourhood Policy
- Impact on the Mediterranean Strategy for Sustainable Development
- Impact on the Mediterranean Solar Plan

4.1 "Socio-economic impacts"

Contribution to economic development and security of supply

The foreseen scarcity of freshwater resources in Southern and Eastern Mediterranean countries is challenging food independency and social stability of a growing population within the region. To reduce the pressure on the environment caused by the overuse of water resources, one of the main issues is to produce and use efficiently freshwater. But it is not sufficient, and the pressing need for seawater desalination is leading to higher energy demand and to an unavoidable additional burden for the national economies. Water security based on fossil desalination is not a sustainable solution, all the more so it enhances the conflicts existing between domestic consumption and export of fossil fuels.

The fluctuating fuel prices, leading to cost traps in the energy sector, are challenging the economies and are difficult to manage, but the traps originating from the forthcoming freshwater scarcity will be worse, due to the vital character of water even at a lowest economic level of development. The growth of population and the economic growth will lead in a high increase of energy demand in the Mediterranean region. To respond to these challenges, Mediterranean Countries will require large amounts of low cost energy for electricity consumption but also for seawater desalination, accompanied by an enhanced water infrastructure and optimal water management.

If they are used in a sustainable way that is compatible with environmental and socio-economical constraints, both solar energy and saltwater could be considered as unlimited resources. Most renewable energy sources will become more cost-effective than fossil fuels within a reasonable time span, well-knowing that in a lot of countries fossil fuels are a subsidised form of energy. Taking into account this trend, it is obvious that renewable energies are the least cost option for energy and water security in South West Mediterranean countries. With increasing electricity intensity in a developing world, their importance will steadily grow, and will be only limited by demand and not by resources.

In most South Mediterranean countries, natural water resources are already now exploited beyond their sustainable yield. In the future, overexploitation of natural water resources must be avoided and growing demand must be additionally covered by seawater desalination. This will require efficient and environmentally compatible desalination technologies and a plentiful, sustainable and affordable energy source. Fossil or nuclear fuels cannot cope with any of these criteria. On the contrary, already today they are subsidised due to their high cost, they are causing serious national and international conflicts and climate change, and oil, gas and uranium are expected to become increasingly scarce and expensive within the next 50 years. A strategy based on fossil or nuclear energy would not lead to an affordable and secure water supply system, but they can be a component of such a strategy. Again, renewables and in a first place solar thermal power are the key to reduce the conflict potential of energy and water scarcity in Mediterranean region and in a wide point of view in the MENA region.

Combined solar power and desalination plants will not only tackle the problems related to a sustainable energy supply at a low cost, but also those related to clean water and to the conservation of productive soils. In the world's arid regions, such plants could and should become the nucleus of a totally new social paradigm: the conservation and recuperation of land endangered by desertification. Providing power, water, shadow and foreign exchange from the export of green power and revived agriculture, such plants can provide all what is needed to effectively fight desertification and to regain land for human settlement and agriculture that otherwise would be lost to the desert. Concentrating solar multipurpose plants in the margins of the desert could generate solar electricity for domestic use and export, freshwater from seawater desalination and provide shade for agriculture and other human activities. Such plants could turn waste land into arable land and create labour opportunities in the agriculture and food sector. Tourism and other industries could follow. Desertification could be stopped.

The growth of energy demand will be accompanied by a rise of greenhouse gas emissions. In a world more and more attentive to climate change, and fewer and fewer constrained in terms of CO_2-emissions, the rise of fuel prices and possible additional costs for CO_2-sequestration would burden economic development of most of the countries. Renewable energy technologies have positive learning curves which lead to declining costs contrary to the fossil fuels. Renewables will replace the fossil fuels in the power sector in the mid-term and Mediterranean countries will benefit by reducing their energy subsidies. For oil and gas exporter countries, they will keep their first export product instead of burning it, and in a long term view maybe export solar electricity.

Development of employment and poverty reduction

With its growing population and within the present high level of unemployment, job creation is a priority for the Mediterranean countries. The implementation of the identified projects and the development of the CSP and water desalination market in the Mediterranean region can contribute significantly to economic development and job creation in these countries (new activities, less exodus, increase of incomes, industry, maintenance …).

The development of a sustainable energy and the deployment of an access to clean energy and water would enable to improve the quality of life of the population. This will also contribute to the social development, especially in case of projects allowing access to electricity and water to population with no (or not enough) access at present.

Contribution to the protection of environment

The development of CSP and water desalination projects in the Mediterranean countries would greatly contribute to the protection of the environment both at the global level by reducing the emissions of CO2 and at the regional and local levels, by reducing the emissions of other pollutants such as NOx and SO2. The development of such projects is a priority due to the large solar resources available in the region and to the fact that such plants would avoid the construction of thermal power plants on the Mediterranean coast which has to be protected.

4.2 “Political impacts”

Contribution to EU policies

The European Union (EU) considers sustainable energy as one of the primary areas to address key economic, environmental, policy and social issues. Sustainable energy, through new and advanced technologies, and medium to long term research into these energy technologies and techniques, forms a cornerstone of Europe’s energy policy strategy. The EU sees the development and deployment of new and advanced sustainable energy technologies and techniques as an important means for addressing issues of energy diversification and security, and for integrating the EU’s policies and sustainability framework in a growing geographic, economic, policy and social framework. The EU, and its 27 Member States, clearly understands that sustainable development knows no boundaries, and that co-operation and integration amongst the Member States, the Candidate Accession States (CAS), and the neighbouring countries of the Mediterranean and the East are all important elements to Europe’s own successful sustainable development.

Moreover, energy is one of the six priority sectors of the Euro-Mediterranean partnership set up in 1995 and the importance for the European Union of a sustainable development of the Mediterranean region and the need to promote renewable energy sources was confirmed at the meeting of the Ministers in charge of energy of the member states of the EU with the Ministers of the Mediterranean Partners countries which took place in Brussels in May 1998.

In the Communication from the Commission to the Council and to the European Parliament of 7 March 2001, "Enhancing Euro-Mediterranean cooperation on transport and energy”, the EC underlines that sustainable development for partner countries in the energy sector is based on energy efficiency requirements, energy saving and environmental protection. Renewable energy has a major role to play and also represents the diversification of energy sources. The use of this energy should therefore significantly contribute to the restructuring of the sector. Cooperation between the EU and the partner countries may also include the use of flexibility mechanisms in the framework of the Kyoto objectives.

The EU is also important actor of the Union of the Mediterranean and supports its priority project Mediterranean Solar Plan with which MED-CSD is fully in line and to which it brings an added value.

Impact on the new European Neighbourhood Policy

This new policy was launched in March 2003 with a Communication from the European Commission to the European Council ad the European Parliament: “Wider Europe-Neighbourhood: A New Framework for Relations with our Eastern and Southern Neighbours”.

The aim of this European Neighbourhood Policy is to set out a new framework for relations over the coming decade with countries who do not currently have a perspective of becoming Members of the European Union but who find themselves sharing a border with the enlarged European Union. The neighbour countries concerned are Russia, Belarus, Ukraine, Moldova, Georgia, Armenia and Azerbaijan, as well as the Southern Mediterranean countries (i.e. the countries which signed the Barcelona Declaration, excluding those that have since joined the European Union, and Turkey).

This New European Neighbourhood Policy is being taken forward via country and/or regional strategic Action Plans, developed by the Commission in close dialogue with all the countries concerned in order to reflect the existing state of relations with each country, its needs and capacities as well as common interests. The Action Plans include political and economic benchmarks by which to judge progress. They define the way ahead over the next three to five years. The next step, when Action Plan priorities are met, could consist in offering a new privileged partnership in the form of European Neighbourhood Agreements, to replace the present generation of bilateral agreements. For the "Mediterranean Partners" this means that the existing Association Agreements with the European Union could be replaced by the new European Neighbourhood Agreements, which will represent the Union's main policy relations documents over the medium term.

The energy sector has a very important, strategic place in the European Neighbourhood Policy. The enlarged European Union is even more dependent on energy imports than the Union before the enlargement. And that energy dependence will grow in the future. On the other side, within the group of "neighbouring countries" there are the most important gas suppliers and transit countries, as well as oil producing countries. The energy complementarities between the pre-enlargement Europe and the Mediterranean Partners is also present (and even stronger) between the enlarged Europe and the new neighbouring countries, whose role of energy suppliers to Europe will grow significantly in the future.

On 19 April 2007, the German Presidency of the EU has announced that a consensus has been reached for giving high priority in the European Neighbourhood Policy to renewable energy and energy efficiency. An amount of 11.2 billion Euros will be dedicated to this objective up to 2013. Solar and wind energy are among the highest priorities foreseen within this cooperation.

The MED-CSD project results can be useful for the drawing up of the Action Plans with the countries and regions concerned and can also be a tool for the EC in the definition of the targeted actions to promote towards developing CSP and water desalination in the Mediterranean region, which will benefit both the Mediterranean region (access to electricity and water, sustainable development, economic and social impacts, environment benefits, …) as a whole and Europe (industry, transfer of technology, investments, security of supply …).

Impact on the Mediterranean Strategy for Sustainable Development

The Mediterranean coastal countries and the European Commission decided at their 12th meeting in 2001 to prepare a "Mediterranean Strategy for Sustainable Development" (MSSD). This strategy was adopted by the Contracting Parties at their 14th conference in Portoroz in November 2005. It was also recognised by the Barcelona +10 Summit.

The MSSD hinges on four objectives and seven priority action domains. Thirty-four indicators are appended to enable strategy follow-up. These will be re-read by the MSSD every two years and revised every five years.

The four main objectives are to (i) help promote economic development by exploiting the assets of the Mediterranean, (ii) reduce social inequalities by attaining the Millennium Objectives for developing and reinforcing cultural identity, (iii) change non-sustainable methods of production and consumption and ensure sustainable management of natural resources, (iv) improve governance at local, national and regional levels.

In the field of energy, the actions and directions proposed by the MSSD are as follows:

- Promote energy efficiency policies and clean energy development to establish global, sector-based objectives and local strategies for sustainable development. A desirable objective would be to reduce energy intensity by 1 to 2% per year by 2015. Regarding renewable energy sources, the objective would be that they satisfy 7% of the total demand for energy by the same date.

- Reinforce regional co-operation and stress the implementation of the United Nations Framework Convention on Climate Change (UNFCCC) and its Kyoto Protocol, as well as the synergies with the Mediterranean Renewable Energy Program (MEDREP) and the Rome Euro-Mediterranean Energy Program (REMEP).

- Promote access to electricity with the objective, by 2015, of halving the number of people without electricity compared with 1990.

It is clear that the MED-CSD proposed project objectives are fully in line and complementary to the objectives of the MSSD (which also includes water as a major topic), it is attempted to establish links with the MSSD Secretariat in order to disseminate our results which will be benefit both for the MSSD and the MED-CSD project.

Impact on the Mediterranean Solar Plan

The Mediterranean Solar Plan (MSP) is one of the key projects proposed within the Union for the Mediterranean, and intends to increase the use of solar energy and other renewable energy sources for power generation, improve energy efficiency and energy savings, develop electricity grid interconnections and foster and encourage the transfer of know-how and technology towards developing countries.

The final target is the development, by 2020, of 20 GW of new renewable energy installed capacity in the Southern and Eastern Mediterranean countries. Up to now, out of more than 150 potential projects for renewable presented by project developers, financial investors and national governments some 25 have been selected.

To accompany and push the MSP the EC ENPI (European Neighbourhood and Partnership Instrument) issued in March 2010 the service procurement program “Paving the way” dedicated to Algeria, Egypt, Israel, Jordan, Lebanon, Morocco, occupied Palestinian Territory, Syria and Tunisia. The purpose of the program -5 million euro on 3 years- is to set the conditions favourable to the increased use of renewable energy in general and solar energy in particular in Southern Mediterranean partner countries.

Achieving that includes the establishment of a harmonized legislative and regulatory framework, strengthened institutional capacity, improvement in knowledge transfer and capacity building in renewable energy technologies, and an improved business climate.

The MED-CSD project allowed identifying a portfolio of projects that may be eligible to the MSP and in particular the Tan Tan CSP/RO Project in Morocco is one of the most advanced projects. Thus the project already proved to be useful for ongoing initiatives and its results in general are useful to the MSP.