SOLAR POWER

FROM EUROPE'S SUN BELT

European Solar Thermal
Electricity Association

ESTELA

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FROM EUROPE'S SUN BELT

Solar Thermal Electricity

- Can be small scale
- Can be large scale
- Is human scale
- Comes from the sun
- Is predictable
- Is forever and can be stored
- Looks like gold but is also green
- Is enormous
- Is beautiful

STE: A COMMERCIAL TECHNOLOGY WITH A HUGE WORLD POTENTIAL

Solar Thermal Electricity has the largest potential and the most suitable characteristics to convert solar radiation into electricity. Solar thermoelectric power plants are fully dispatchable, perfectly meet the demand curve and can additionally provide other fluent renewable conversion technologies with the necessary back-up.

The Present Situation of STE

By July 2009, 25 plants of 50 MW each (parabolic trough collector type) and an additional one of 17 MW (central receiver type with 15h storage) are under construction in Spain. Four will be connected to the grid shortly. The total investment for these projects is around 5,000 M€.

Two solar plants are under construction in Algeria and Morocco. Around 20 more projects are in a fairly advanced stage in Spain for a total investment of more than 5,000 M€.

There are a significant number of open tenders and approved projects for utilities and other organisations to build solar thermoelectric plants in countries all around the world (U.S.A., Arab Emirates, China, Australia, etc) with a total power amount of more than 1,000 MW.

Market Perspectives for STE Plants

Electricity generated by STE plants is dispatchable and this can be enhanced by new technologies and/or hybrid concepts using other renewable or conventional fuels. Dual applications will bring important benefits in some specific areas (i.e. electricity and water desalination).

Costs will be brought down by innovation in systems and components, improvement of production technology, increase of the overall efficiency, enlargement of operation hours (storage), bigger power blocks, decrease in the O&M costs, learning curve in construction and economies of scale

CONCENTRATING SOLAR POWER TECHNOLOGIES

Solar Thermal Electricity, also known as Concentrating Solar Power (CSP), is produced using concentrating solar radiation technologies. STE plants provide clean and reliable power in units ranging from 10 kW to 300 MW.

In Europe around 1,500 MW of solar thermal power plants are either recently operating or under construction. The installed capacity in Europe is expected to be of 2 GW by 2012 and around 30 GW could be reached by 2020. The technical potential in Europe in the long run can be estimated at least at twenty times that figure within reasonable generation costs.

PARABOLIC TROUGH PLANTS

- Size: 50 to 300 MW
- Proven utility scale technology
- Commercial operation since 1984
- Preferred technology for new plants in the USA, Europe and North Africa
- 25 plants under construction in Spain

Parabolic Trough plants use line-concentrating parabolic trough collectors which reflect the solar radiation into an absorber tube. Synthetic oil circulates through the tubes and is heated up to approximately 400°C.

Parabolic trough collectors represent the most commonly used thermoelectric technology in the market. Its track record began in the 1980's in the USA with a total power installed of about 350 MW. New plants have been constructed in the last years, such as the Nevada Solar One 65 MW plant built by a Spanish company. In July 2009, 25 plants are under construction in Spain which amounts to 1,250 MW, and a number of new projects are being developed in the USA. In addition, two plants in Algeria and Morocco of 20 MW electrical equivalent power for two solar bottomed combined cycles have been awarded to European companies as a result of an international tender and a 20 MW plant is under construction in Egypt. A tender for a 100 MW plant is under way in Abu-Dhabi as well as additional expressions of interest from Middle East, China and other sunny countries. The current total investment for the aforementioned projects is close to 7,000 M€. Some of the 50 MW power plants under construction in Spain have been designed to produce not only the nominal power during sunny hours, but also to store energy, allowing the plant to produce an additional 7.5 hours of nominal power after sunset, which dramatically improves the integration of solar thermal power plant into the grid. Molten salts are normally used as storage fluid in a hot-and-cold two-tank concept.

Plants in Operation in Europe:

- **Andasol 1**
  (50 MW + 7.5 hour storage)
  Granada, Spain
- **Puertollano**
  (50 MW)
  Ciudad Real, Spain
- **Alvarado**
  (50 MW)
  Badajoz, Spain

CENTRAL RECEIVER PLANTS

- Size: 10 to 50 MW
- Demo plants built in the 1980's
- First commercial 10 MW and 20 MW plants in operation in Spain and another one under construction (17 MW + 15h storage)
- Larger projects announced in the USA

Central Receiver plants, also called tower plants, use big mirrors (heliostats) larger than 100 m^2 that are almost flat and track the sun on two axes. The concentrated radiation beam hits a receiver atop a tower. The working fluid temperature depends on the type of fluid that is used to collect the energy and is within the range of 500 to 600°C.

The PS 10 and PS 20 in Seville are the only commercial power plants of this kind in operation today. Their nominal power output is 10 MW and 20 MW and they are designed with a northern heliostat field and saturated steam as working fluid in the receiver. The storage system is only designed to cope with transient situations. Another 17 MW plant, Torresol, is under construction. It is located in the province of Seville, with a circular field type equipped with a molten salt receiver and have a storage capacity of 15 hours.

The size of these plants might be limited by the maximum distance from the tower to the last row of heliostats.

At this time, it is premature to already establish reliable cost/power ratios for this technology as the number of operational or ongoing projects is small, but it will not be too different from the parabolic trough plants. The land use is slightly less effective in the case of solar tower plants. On the other hand this technology does not require a flat land surface as it is the case for parabolic trough plants. A further advantage is the potential increase of the overall conversion efficiency (up to 20%) that can be achieved by raising the working fluid temperature. The commercial confidence in this technology is growing as more operational plants are being built and consequently it will improve in the near future. Hybridisation is feasible, but no commercial projects have been built so far.

Plants in Operation in Europe:

- **Solucar PS10 and PS20**
  (10 MW + 20 MW)
  Sevilla, Spain

DISH STIRLING SYSTEMS

- Size: 10 KW to 25 KW per unit
- Several small scale installations in operation; utility-scale installations slated for construction in 2010
- Applications appropriate for both utility-scale projects and stand-alone distributed energy projects

The Dish Stirling System consists of a solar concentrator in a dish structure that supports an array of curved glass mirrors. The parabolic dish tracks the sun throughout the day and concentrates the radiation onto the heat absorption unit of a Stirling engine. The focused solar thermal energy is then converted to grid-quality electricity. The conversion process involves a closed cycle, high-efficiency solar Stirling engine using an internal working fluid (usually hydrogen or helium) that is recycled through the engine. The working fluid is heated and pressurised by the solar receiver, which in turn powers the Stirling engine.

The Dish Stirling Systems have decades of recorded operating history. Dish Stirling Systems are flexible in terms of size and scale of deployment. Owing to their modular design, they are capable of both small-scale distributed power output, and suitable for large, utility-scale projects with thousands of dishes arranged in a solar park (two plants in the US totalling over 1.4 GW are slated to begin construction in 2010).

This technology uses no water in the power conversion process (either for steam generation or cooling) and the only water needed is for the washing of the mirrors. Dish Stirling technologies are furthermore attractive due to their high efficiency and modular design, which gives the systems several key advantages, including a higher degree of slope tolerance and site flexibility, meaning it does not require flat land, significantly reducing grading costs and environmental impact; high overall availability due to the fact that there is no singular point of failure and scheduled maintenance on the dishes can occur on individual units while the others continue to generate power; and a low-cost of manufacture and deployment as a result of high-throughput automotive style production and assembly.

LINEAR FRESNEL SYSTEMS

- Current demo projects up to 6 MW
- Larger plants under development (up to 150 MW)

Linear Fresnel collectors are line focusing systems like parabolic troughs with a similar power generation technology. The difference with parabolic troughs is the fixed absorber position above a field of horizontally mounted flat mirror stripes, collectively or individually tracked to the sun.

Fresnel technology, which is now being tested under actual operating conditions, is comparatively simple to manufacture, build and operate. The reflectors, which collect and focus the sun's rays, are completely flat and, arranged in a linear pattern, they form long, moveable rows of mirrors. The parallel mirrors focus the radiated energy from the sun onto a pipe, positioned eight meters above the mirrors. Water flows through this absorber pipe, which is heated to temperatures of up to 450°C. This produces steam (as in a conventional power plant), which is converted into electrical energy in a steam turbine. Fresnel collectors are innovative in that they are not sensitive to wind and require a smaller area of land than other solar collectors.

Apart from the generation of solar power, the area below the mirrors can be used in a variety of ways. In desert like environments the shaded area under the mirror fields, where the sun irradiation is reduced by over 80%, could be used for storage, parking, office buildings (with reduced cooling costs) or even green house agriculture.

So far in Europe no fully commercial plant based on the Fresnel principle is being developed. Demonstration plants in the several MW-scales are being built in Europe and the USA to evaluate and prove electricity generation costs, to gain operation experience and commercial confidence.

STE CONTRIBUTING TO REACH THE EU TARGETS: 20% OF RENEWABLE ENERGY SOURCES BY 2020

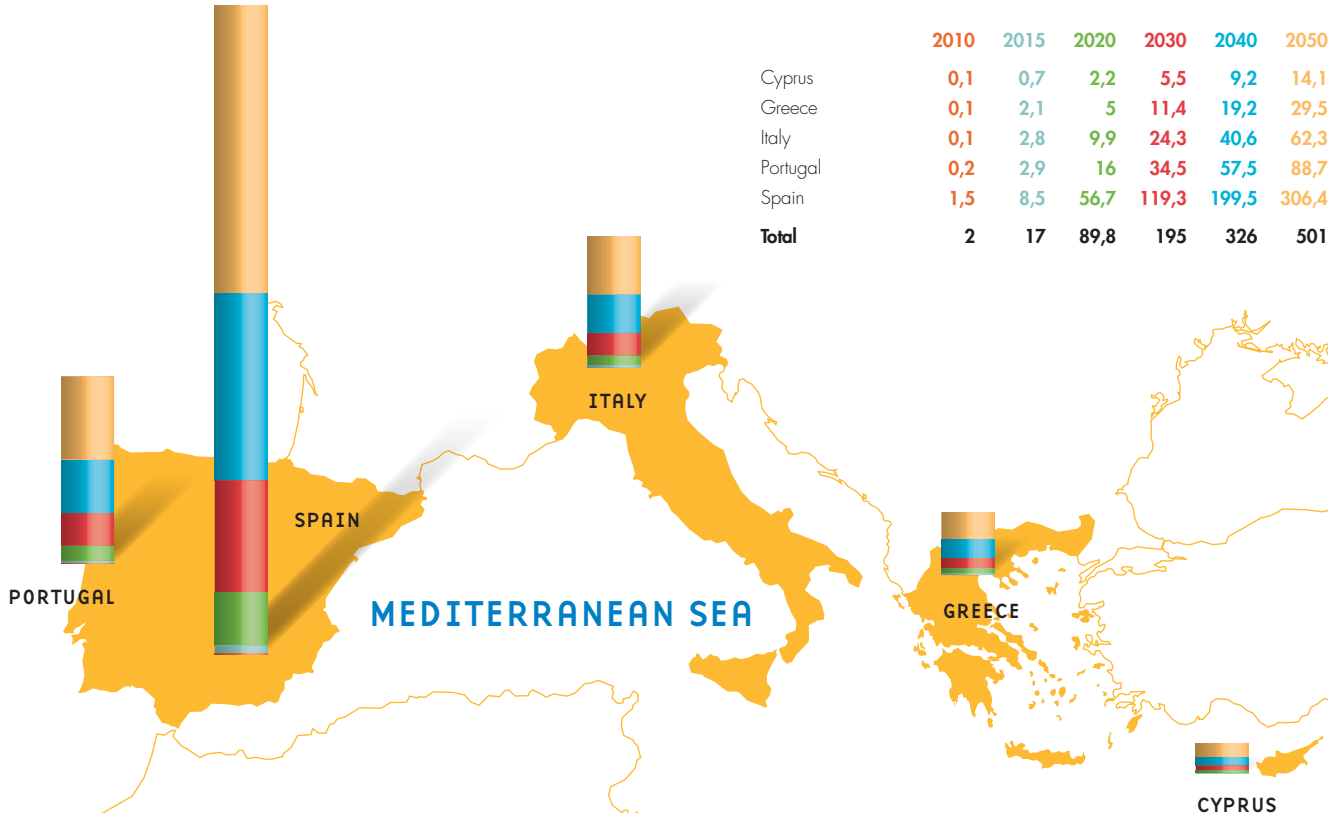
By 2010 there will be more than 500 MW connected to the grid, and the short-term potential in European countries is estimated at 30,000 MW that could contribute, if the necessary measures are taken, to the EU 20% target in the year 2020.

Solar thermoelectric generation is highly predictable, and can be coupled with thermal storage or hybridisation, with gas or biomass, enabling stable national or European electricity networks. Solar thermoelectric plants have favorable inertial response as well as the capability for primary, secondary and tertiary electrical regulation in both directions, up and down.

Solar thermoelectric power plants can meet the demand at any time, day and night, and can supply electricity at peak hours if they are anticipated. Furthermore these plants can easily meet the demand curve and contribute to the electrical system's stability through the input of substantial amounts of other less dispatchable renewable resources in the electrical systems, both at European and at regional level, when allowed by the Supergrid development, including the Southern Mediterranean and Northern Baltic areas.

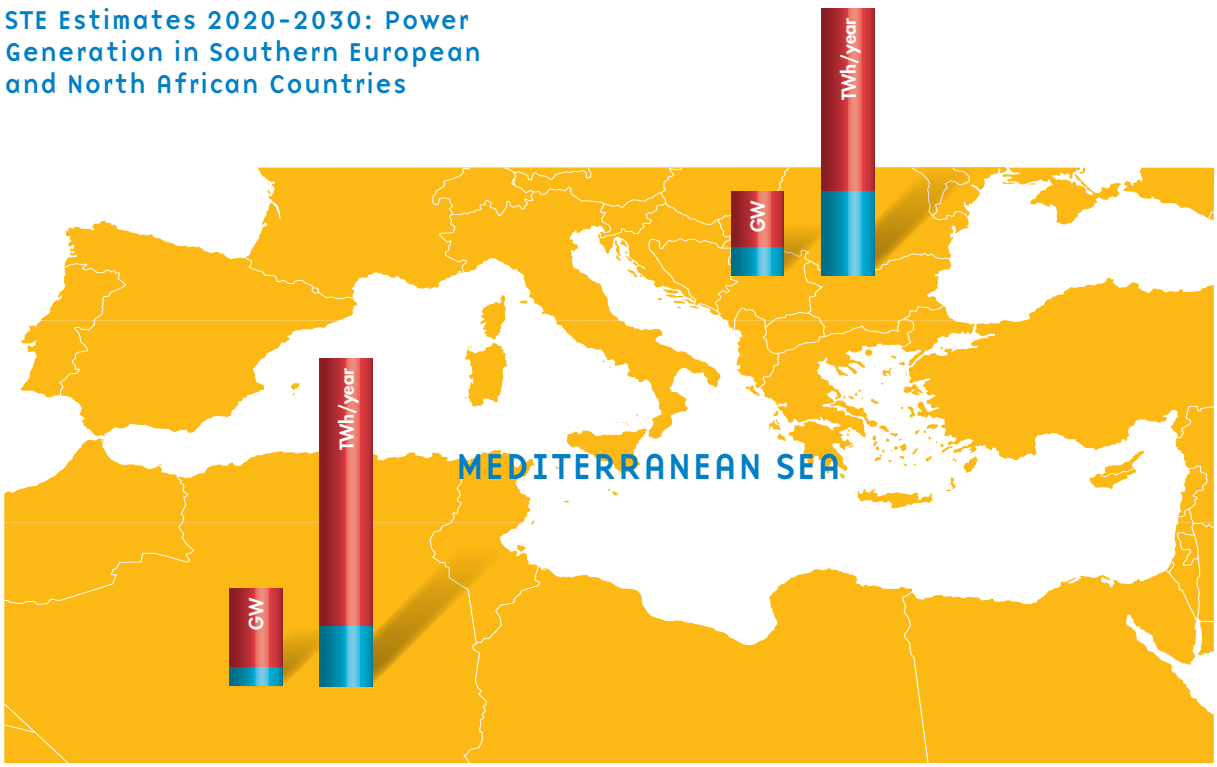
STE Estimates 2010-2050: Power Generation Capacity in Southern Europe (TWh/Year)

	2010	2015	2020	2030	2040	2050
Cyprus	0,1	0,7	2,2	5,5	9,2	14,1
Greece	0,1	2,1	5	11,4	19,2	29,5
Italy	0,1	2,8	9,9	24,3	40,6	62,3
Portugal	0,2	2,9	16	34,5	57,5	88,7
Spain	1,5	8,5	56,7	119,3	199,5	306,4
Total	**2**	**17**	**89,8**	**195**	**326**	**501**



STE DEVELOPING A REGIONAL LONG-TERM STRATEGY FOR A FULL RENEWABLE ENERGY SYSTEM AND SUSTAINABILITY

STE Estimates 2020-2030: Power Generation in Southern European and North African Countries



A world-wide long term strategy is needed to build a sustainable fully renewable energy system in order to secure the energy supply and to meet the challenges of climate change. For the EU long-term renewable supply regional approaches are of paramount importance (i.e. Baltic Region, East and Central Europe, and the Mediterranean Ring), In the long-term the Supergrid will be the most economic and efficient way to connect the 'enlarged' Europe and neighbouring countries.

Focusing on Solar Thermal Electricity, the EU and its Member States should take advantage of the fact that the largest potential of the world is in Southern Europe and the Union's neighbour countries of the Mediterranean, today partners in the Union for the Mediterranean.

		2020	2030
Installed capacity of STE plants in Europe	GW	30	60
Electricity generation - STE in Europe	TWh/year	89,8	195
Installed capacity of STE in NA countries	GW	20	85
Electricity generation- STE in NA countries	TWh/year	64	286

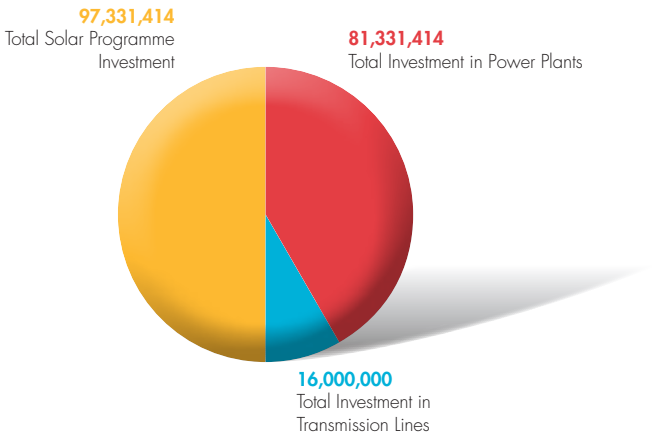
North African (NA) countries should develop clean technologies to face the increasing domestic energy demand. In the medium-term, while a target of 30 GW for 2020 in the EU is feasible, a much larger contribution could be obtained in the longer-term if the potentials of the North African countries are developed. A target of 20 GW for 2020 and 85 GW for 2030 is feasible taking into account the grid infrastructure to be developed in the region.

SOLAR POWER: THE MAIN RESOURCE IN THE MEDITERRANEAN REGION

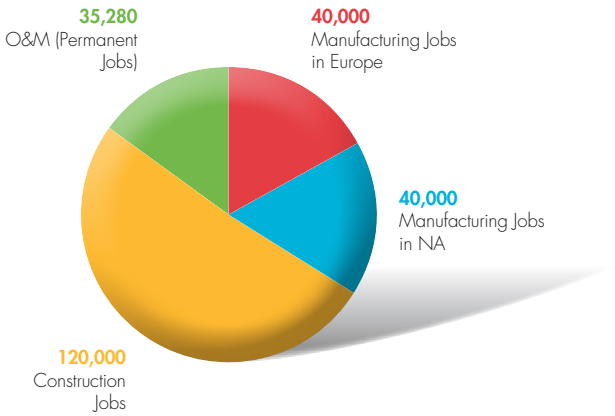
Mediterranean Solar Plan: Costs and Benefits

20 GW of solar thermal plants installed in 2010-2020

Cost Projections by 2020
(cost per kWh for the initial 20 years)



Employment Projections by 2020 (man/year)



Solar energy is the main resource in the Mediterranean region with one of the biggest potentials in the world.

ESTELA's proposal for the Mediterranean Solar Plan (*) could contribute to improve the security of the energy supply as well as to meet the increasing domestic demand through renewable energy sources and to boost economic development in the UfM countries.

A MSP based mainly on STE could generate new income resources and reinforce the grid infrastructure in these countries, as well as create a new regional industrial sector of solar components manufacturing.

The MSP-STE could also help EU countries achieve the renewable energy 2020 targets. According to Article 9 (Joint projects between MS and third countries) of the new RES Directive that will enter into force in 2010, EU Member States will be allowed to import energy from third countries.

But the main benefit from the MSP-STE will be to create a regional market for STE electricity that will allow a faster evolution to reduce costs, improve dispatchability and reduce water consumption, thus leading to a fully competitive kWh cost for plants built by 2021 and beyond.

A managing body that ESTELA proposes, called E-SECURE, could set up long-term agreements with countries. Mainly acting as a trader E-SECURE will buy the electricity from the companies owning the plants and sell it on the local and European markets.

(*) The Union for the Mediterranean and the Mediterranean Solar Plan. On 13 July 2008 the Heads of States of the European Union and of the Mediterranean countries agreed to strengthen the process of Barcelona initiated in 1995 and to transform it into the Union for The Mediterranean: an area of peace, democracy, cooperation and prosperity. The permanent Secretariat established in Barcelona will be responsible for carrying out the feasibility studies and elaborating 6 regional projects, among them the Mediterranean Solar Plan.

ESTELA

European Solar Thermal Electricity Association

Join ESTELA
www.estelasolar.eu

ESTELA is the industry European Solar Thermal Electricity Association that was created in 2007 and started operating in Brussels in March 2008.

ESTELA currently has 47 members. One of these members, the national Spanish association PROTERMOSOLAR has more than 60 members itself. Thus, ESTELA represents -directly and indirectly- more than 100 companies, in fact most of the European companies that have activities in the solar thermal electricity sector. The solar thermal electricity industry is a European-wide industry.

ESTELA's members are located in Spain, Germany, Italy, France, Portugal, Greece, the United Kingdom, Ireland, Belgium, the Netherlands and Algeria.

One of the main activities of ESTELA is to closely collaborate with the EU Institutions in order to obtain mutual benefits. ESTELA believes that developing Solar Thermal Electricity technologies will help achieve most of the EU policies and initiatives in the field of energy.

ESTELA's main objectives are in line with EU priorities in the fields of energy, environment, climate change, sustainability and economic growth based on innovation.

ESTELA's objectives:

- To promote high and mid temperature solar technologies for the production of thermal electricity to move towards sustainable energy systems,
- To promote Solar Thermal Electricity in Europe at policy and administrative levels (local, regional, national and EU),
- To promote the EU's actions in favour of a European industry development and to contribute to reach the EU's energy objectives and its main renewable energy and environment targets,
- To support research and innovation, including training, and favoring equal opportunities,
- To promote excellence in the planning, design, construction and operating of Solar Thermal Electricity plants,
- To promote Solar Thermal Electricity at international level, mainly in the Mediterranean area and developing countries,
- To cooperate at international level to fight against climate change,
- To represent the Solar Thermal Electricity sector in Europe and worldwide.

Members of ESTELA

Become a Member of ESTELA

Membership is open to companies and institutions from the European Union and Union for the Mediterranean countries

Download the Membership Form at

www.estelasolar.eu

Mixed Sources
Product group from well-managed forests, controlled sources and recycled wood or fiber
FSC

Design : www.acg-bxl.be

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