THE ESSENTIAL ROLE OF SOLAR THERMAL ELECTRICITY

A real opportunity for Europe

October 2012

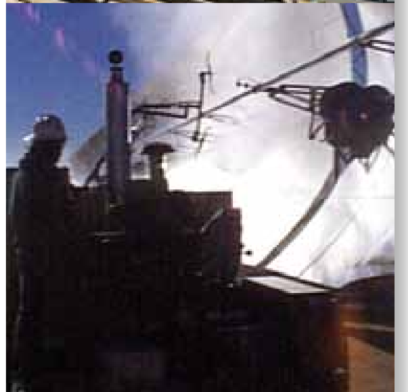
European Solar Thermal Electricity Association
ESTELA

FOREWORD

The objective of this document is to state clear arguments which support the value proposition of Solar Thermal Electricity (STE) plants to policy makers and the public opinion by:

- Providing direct and reliable information from the STE Industry on current and future costs, which corrects some old and misleading data from different organizations.
- Highlighting the distinct technical features of STE plants in order to present them as the backbone of the future energy generation mix in the Sun Belt countries.
- Showing the great opportunity of STE technologies for the European industry in the near future and their potential for fostering industrial development in the countries which support their deployment.



EXECUTIVE SUMMARY

Overcoming the economic crisis and achieving a greenhouse gas emission-free electricity generation system are the two main challenges at country and at world level. As energy is a main driver for development, they are strongly linked to each other and Solar Thermal Electricity (STE) plants can provide a significant contribution to achieve these two goals.

Among all renewable energies, **STE stands out for its distinct technical features, such as dispatchability – through storage and/or hybridization – and grid stability, as well as for its high macroeconomic impact on the economy,** largely adding to the country's GDP through high investments, fiscal contributions, fuel imports reduction and the creation of jobs in component manufacturing and in the construction and operation of the plant.

STE plants have proven their reliability since the 80s. Nowadays, contributions to the global total consumption of over 4 % are usually achieved in Spain perfectly matching with the demand curve along the day.

Regarding costs, a remarkable reduction has been achieved by STE since 2007 with only 3 GW installed worldwide. In comparison, the current cost level of Wind and PV is the result of a long trajectory along their learning curves. **Today's prices for electricity produced by STE plants fill in the range from 15 to 20 c€/kWh** depending on the irradiation level and they will continuously decrease in the coming years. The added value of dispatchability and the golden end after the feed-in tariff period has expired provide additional economic arguments towards the near term competitiveness of this technology.

Innovations on plant concept, new plant integration solutions, new working fluids, new materials to reduce cost and increase performances of components and new techniques for operation control will make this happen.

STE power plants are boosting industrial development. And the positive impact on the economy largely compensates the financial support of STE which is still needed in order to reach its full development. This support will be progressively lower over time and will disappear by around 2020 in Europe while in other countries STE will become competitive much earlier.

The European STE industry is indisputably the world leader in its technology, but this advantageous position could be weakened, if support for the sector is not further provided. **It is necessary to continue building in Europe new generation plants with the most advanced concepts** in R&D, engineering and component manufacturing to preserve and foster this leading position of the industry.

Policies at EU and Member State levels shall provide the necessary financial, infrastructure and operational instruments to take advantage of the solar resource in the Southern European countries reducing the energy dependence from natural gas and supporting the deployment of the European STE technology all around the world.

STE can help overcome the economic crisis and achieve an emission-free generation system.

GENERAL CONTEXT

The evidence of the impact of human activity in the composition of the atmosphere and thus on the climate are forcing the adoption of measures to mitigate greenhouse gas (GHG) emissions in different industrial activity sectors, especially in electricity generation, road transport and household energy use. As in the transport and household sectors, the use of electricity is progressing, since it is less polluting; consequently, obtaining an electricity generation system free of GHG emissions must be the primary goal of the new energy model.

Europe is undergoing a severe financial crisis with an economic growth rate below other references of regions in the world and with some Member States facing recession. It is therefore necessary to find leverage mechanisms which will help overcome the crisis and contribute to sustainable growth towards an environmentally friendly and competitive economy in the long term.

Overcoming the economic crisis and achieving a GHG emission-free electricity generation system are the two main challenges, and they are strongly linked to each other.

The present electricity generation mix is highly dependent on coal-fired thermal power plants, plants based on the natural gas combined cycle and nuclear power plants. This is true not only in Europe but in many other regions. The mix strongly relies on fossil fuel imports. Imports, which not only hurt the European economy due to their high and volatile prices and because of currency outflow, but also place Europe in a vulnerable position regarding security of supply. In addition, nuclear power, a pillar of electricity generation in some European countries, has an unclear future as phasing-out has already begun and could be even accelerated. The life extension of nuclear power plants is everyday less likely and some plants may even close before their planned end.

Decisions concerning the electrical generation mix have a substantial influence on the economy of European countries. Fossil fuel imports have a negative impact on gross domestic product (GDP). As an example, for every Euro that is paid to a combined cycle power plant in Spain, approximately 80 cents leave the country. In Germany, the decision to abandon nuclear power has driven a high demand for renewable energy.

Renewable energies still need some support – in the form of premium tariffs or other kind – to make up for their initial capital costs which are in general higher than those of conventional power plants because they have already included the "fuel cost". This support will be progressively less and less necessary and it will most likely no longer be required in the medium term as prices for fossil fuel increase.

In return, although it may seem paradoxical, renewable technologies reduce the costs of the electricity in the electricity spot markets, where the last plant matching the demand provides the price for the complete generation at this time, as renewable energy plants have no marginal costs for fuels. So the larger the share of renewable electricity is, the lower the pool price of electricity is (merit order effect). Sometimes, as when this happens in Spain, the reduction may be higher than the costs associated to the premiums that renewable energies receive. Therefore, these premiums have a lower impact on the final consumers, both in households and businesses.

STE power plants have the largest positive macroeconomic impact on country's economies.

Additionally, renewable energies provide stable and known costs allowing planning the future of the electricity supply, while the future price uncertainties of fossil fuels hamper investment decisions in many other economy sectors.

Support of the deployment of renewable energy generation technologies with adequate and progressively decreasing Feed-in Tariffs (FiT) will mobilize private investments in productive assets.

In this time of economic crisis, incentives for renewable energies must not be envisaged as a load to the electricity system but rather as a catalyst for economic growth and job creation, as well as the path towards sustainability. Rather than a cost issue, renewable energies have to be seen as a contribution to overcome the economic crisis.

Among all renewable energies, solar thermal electricity (STE) stands out for its high macroeconomic impact on the economy, largely adding to the country's GDP through high investments, fiscal contributions, fuel imports reduction and the creation of jobs in component manufacturing and in the construction and operation of the plant.

STE is the technology that may help pave the way out of the economic crisis in the Southern European countries. Moreover, STE represents a historic opportunity for the European industry to reinforce its business presence through collaborative approaches in the whole world and particularly in the neighbouring Middle East and North Africa (MENA) region, given its current leading position in this market.

An accurate vision of the future energy model and an established roadmap to reach cost-efficiency would provide Europe with a clear competitive advantage, not only for its internal market but also for the business of European companies' world leadership in a strategic field. This roadmap should provide long-term investment security for promoters and investors, enabling their full commitment to the projects and avoiding the usual "stop and go" investment situations.

The STE industry offers predictable and decreasing costs, ensuring a safe transition towards a sustainable model of electricity generation. This is a more attractive alternative for those that will be affected by the rising prices of fossil fuels and that will increase CO_2 emissions. This alternative is also more attractive than non-dispatchable renewable technologies.

THE ESSENTIAL ROLE OF STE PLANTS IN THE ELECTRICITY GENERATION MIX

Solar thermal electricity plants have proven their reliability since the 80s, when, following pilot projects in Europe (Spain, France, Italy), the United States installed the so called SEGS plants in California with a total power close to 400 MW. Those plants are still operative and their performance has even improved in comparison to that in the 80s.

The STE potential of the European and Mediterranean countries is much larger than the energy consumed by the whole EU. If the potential in the MENA region is also taken into account, the STE supply to Europe could be considered as unlimited.

The two major renewable resources that Europe possesses are: the sun, mainly in the South, and wind, mainly in the North. Hydropower and biomass, besides being seasonally compatible, will help to complement to a certain degree these two major resources. Geographical location of both resources appeal for an improved grid connecting Europe, North to South and West to East, to ensure an abundant and robust electricity supply.

Presently, there are close to 2,000 MW of STE plants operative or about to enter operation in Spain and 7,000 MW of overall generation has been reflected in the Member States' National Renewable Energy Action Plans for 2020 to comply with the European Renewable Energy Directive goals.

STE plants can be the backbone of the future energy generation mix in the Sun Belt countries. Besides the enormous, inexhaustible and predictable resource that is the sun, this major role will be based in three main pillars:

- Dispatchability
- Contribution to local economy
- Cost reduction potential

1. DISPATCHABILITY AND OTHER TECHNICAL ADVANTAGES

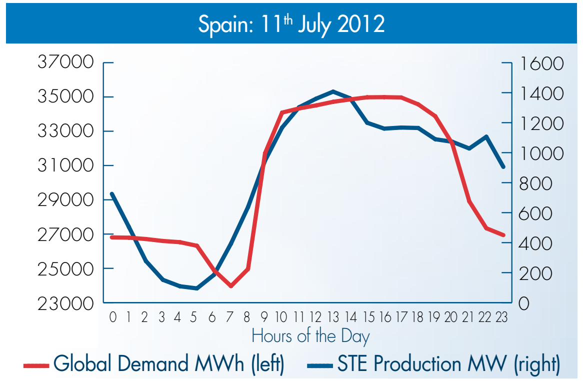
Technically, STE plants are almost fully dispatchable and can perfectly follow the demand curve, with operational time (capacity factor) much higher than 50% all the year long. They could even reach 100% in plant configurations functioning solely on solar energy. The high capacity factor is also an advantage when trying to optimize the transmission network, particularly in countries with a high electrical consumption growth.

Furthermore, STE power plants are able to feed firm electricity to the grid, thanks to their well dimensioned on-site storage and their ability to hybridize with biomass or any other source, renewable or conventional. In some regions hybridization with natural gas or coal might be advantageous.

STE plants can deliver electricity day and night following the demand curve.

STE plants contribute to the grid stability, because of the high mechanical inertia of their generator system, so the voltage and frequency in the grid could be maintained in case of short term incidents. In addition, STE plants can provide the necessary ancillary services to the electrical system in the country to ensure its reliable operation.

Furthermore, STE production curves fit quite well with the demand curve as it can be seen in the figure below where the global demand corresponds to a typical summer day in Spain. The source of this data is from the Spanish Electrical System Operator, REE, and the STE generation corresponds to the whole STE park in operation in July 2012. More than 50% of the plants have a storage system.

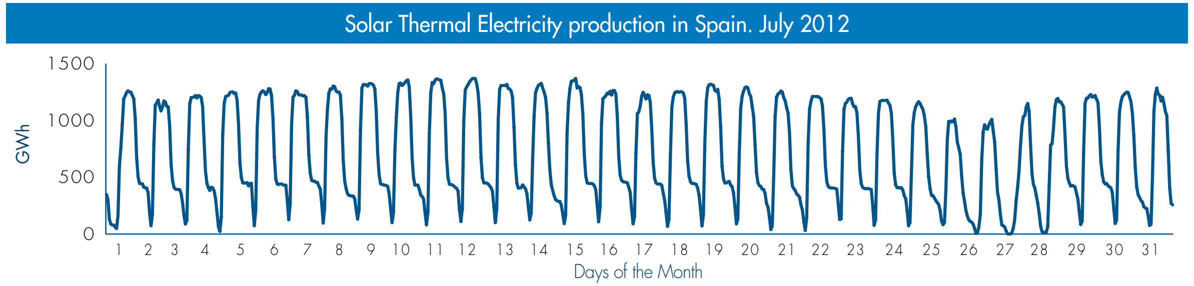


Production of electricity with STE plants is also very stable and predictable (see second figure below, of which the data are also obtained from the REE web page).

These are the main advantages over other intermittent forms of renewable energy, such as PV or wind, which would require complementing an initial investment with conventional power plants in order to provide non-intermittent electricity to the grid. Thus, these intermittent technologies without storage cannot provide a CO_2-free generation system; so far they require a conventional backup capacity.

It is not possible to compare STE and PV directly in terms of cost per kW installed or cost per kWh generated. The current cost of PV reflects the experience from a global power installation which is almost two orders of magnitude larger than in the case of STE. When STE reaches a total power installed in the range of 100 GW, its costs will be significantly lower than today's PV costs. Furthermore, the current costs for PV-modules are artificially low, as almost all manufacturers in the value chain are selling below production costs due to the overcapacity and deteriorating markets.

Nevertheless, STE plants and PV can complement each other, benefiting from the same common solar resource. Distributed PV installations can contribute to supply part of the demand reducing significantly the need of peaking power plants.



2. HIGH LOCAL CONTENT

One main driver for policy makers should be the share of the investment in new generation equipment that remains in the country, contributing to the growth of the local economy.

Unlike other generation technologies, STE plants provide a minimum local content close to 50% from the very first plant installed regardless of the country's specific characteristics.

The economic impact of STE plants is the highest one of the most relevant renewable energy technologies, both in job creation and in the development of local industry during the whole process of plant construction and operation.

If the construction of STE plants is planned at a pace of a few hundred MW per year, the attracted investments for the local fabrication of specific equipment would raise the local content up to a 70-80% in few years. In Spain, approximately 400 MW have been installed yearly since 2008 when the local content was slightly higher than 50%. In 2011 the local content reached 80%.

Countries in the Sun Belt might profit from STE by exploiting the sun resource, attracting foreign investments and creating or fostering their industrial sectors.

As an example, each 50 MW plant with thermal storage installed in Spain is equivalent to 2,250 one-year jobs needed, from the design phase to completion of construction. Once running, the plants require 50 persons/year for their operation and maintenance[1].

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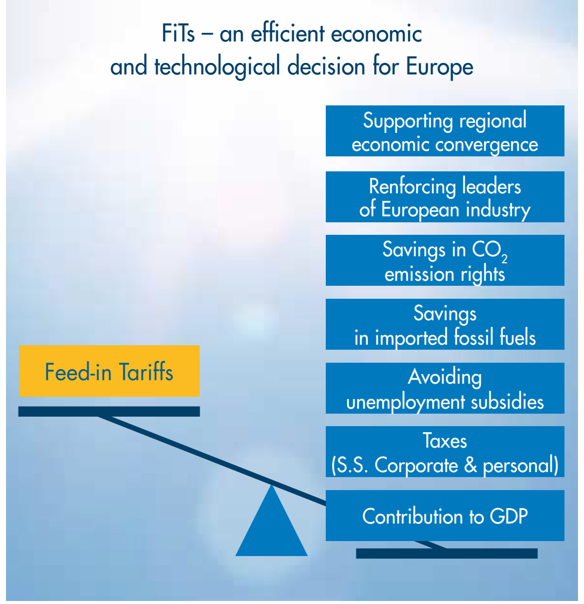
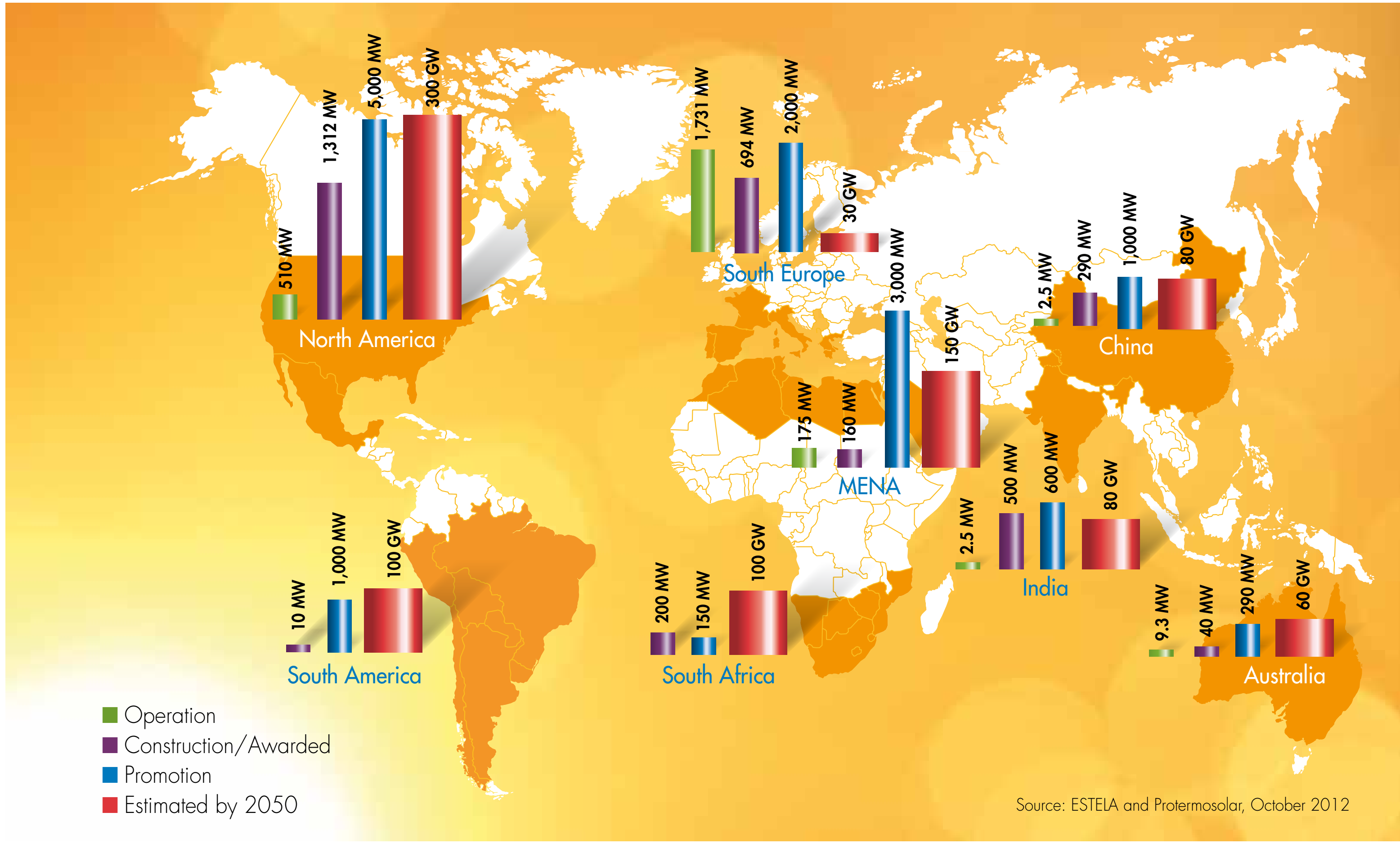


The European STE industry is indisputably the world leader in the technology, but this advantageous position could be weakened, if support for the sector is not further continued. It is necessary to continue building in Europe new generation plants with the most advanced concepts in R&D, engineering and component manufacturing to preserve and foster this leading position of the industry.

[1] *For further information on Spain's STE data and figures, please refer to the Macroeconomic Study of the STE sector in 2010 elaborated by Deloitte: http://www.estelasolar.eu/fileadmin/ESTELAdocs/documents/Publications/2011_Macroeconomic_impact_of_STE_in_Spain_Protermo_Solar_Deloitte.pdf*



Source: ESTELA and Protermosolar, October 2012

The prospects for the deployment of STE plants are very large according to the International Energy Agency. More than 1,000 TWh/year are expected at world level by 2030 and close to 5,000 TWh/year by 2050 with Europe having a minimum share at that time. In the map above elaborated by ESTELA, the breakdown of power installed by regions can be seen.

A significant part of the STE deployment will be located in developing countries where commercial and collaborative approaches can be undertaken for the mutual benefit of both parties.

3. THE COMPETITIVENESS OF STE PLANTS IN THE SHORT AND MEDIUM TERM

A remarkable cost reduction has been achieved by STE since 2007 with only 3 GW installed worldwide. In comparison, the current cost level of Wind and PV is the result of a long trajectory along the learning curve. The current cost level of Wind and PV profited from a learning curve of 250 GW and 80 GW respectively. Wind energy seems to be at the end of its learning curve since some years showing very little reduction of costs. Recently, PV did show a drastic price decrease but this is not expected to be sustained because it was largely the consequence of the desperate economic situation of the manufacturers all over the world.

Power plants in Spain, some of which are still in the construction phase, can no longer be considered as current cost reference for STE technologies. Their FiT corresponds to projects approved in 2009, with designs completed before 2007. They show generation costs of up to 30 c€/kWh for a typical 50 MW power plant.

However, new and larger plants designed and constructed in Southern Europe could show today lower generation costs. The international consultant firm A.T. Kearney carried out a study for ESTELA[2], in which the expected cost reduction for STE plants was analyzed in detail. In this study a cost reduction between 35-50% was expected by the year 2020, in comparison with 2010 prices (the study was based mainly on Spanish references).

In fact, these projections have been surpassed by the projects recently awarded in different regions (India, South Africa and Morocco) and the contractual Power Purchase Agreements (PPA) signed with the utilities in the USA. The price references from these projects, ranging from 13 c$/kWh in the USA to 25 c€/kWh in South Africa, correspond to different irradiation, plant sizes and financial conditions. Some of them include different kinds of support from governmental programs.

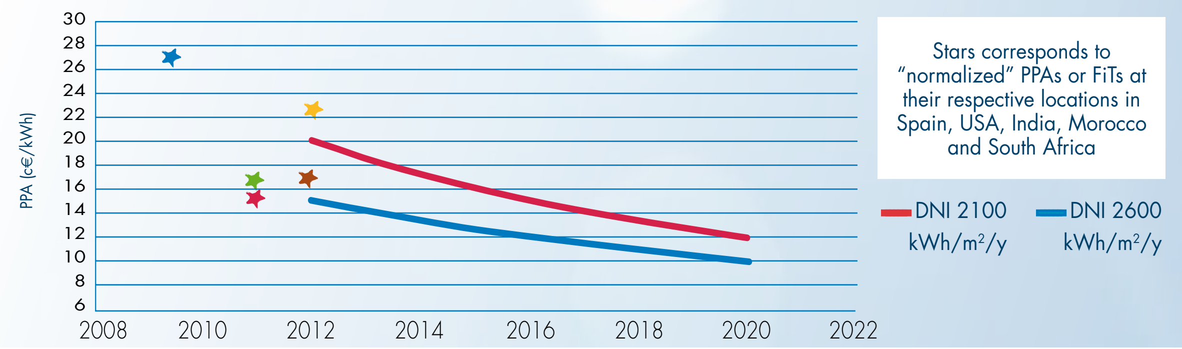
As the costs of the different current projects correspond to very different conditions, they are hard to compare. In order to have clear and comparative figures, it is necessary to harmonize project size, financial and other specific conditions.

This is what we attempted here by defining the "normalized" PPA of these plants. The effects of plant size, PPA duration, financing conditions, inflation escalation, grants, etc., have been accordingly "discounted". Thus, we are in a position to estimate what the real equivalent 25 years PPA price of a typical future plant (150 MW with 4 hours of storage) is, considering commercial financing conditions and no public subsidies. Although these are the main variables affecting the required PPA level, there are still some other parameters – site, country or project specific – which could have some further impact on the "normalized" result shown in the figure.

[2] *Solar Thermal Electricity 2025 Cost Roadmap, elaborated by A.T. Kearney http://www.estelasolar.eu/fileadmin/ESTELAdocs/documents/Cost_Roadmap/June2010_Solar_Thermal_Electricity_2025-ENG.pdf*

Costs of STE plants are decreasing rapidly.
In some countries they are already almost competitive while in Europe it will happen before 2020.

Required value of a 25 years PPA for a 150 MW, 4 hours storage, STE plant without any public financial aids and no escalation



The figures for current projects resulting from this harmonization procedure must be considered only as good estimates because there are other conditions such as promoter's benefit, required local content, etc., which could not be taken into account at this stage.

This exercise provides a realistic picture of real costs as of today. However, reliable cost reduction curves are essential to define the future scenarios of STE penetration in the generation mix of the sunny countries.

That is why ESTELA has gathered the opinion of some of its members – the most active in constructing plants and component manufacturing – on the expected evolution of costs in the coming years to double-check and update the A.T. Kearney figures from 2010.

Instead of using the typical Levelised Cost of Electricity (LCOE) calculations, which have substantial long term uncertainties, we preferred to show the evolution of PPAs or FiTs for a given contractual period that would make it possible to build the plants, i.e. the required sales price of the electricity to the grid. This way of presentation allows policy makers to determine the gap between the PPA and the current markets price, which should be covered by supporting schemes now and in the future, when planning the deployment of STE in their respective countries. In addition, policy makers should take into consideration that STE plants offer a significant "golden end" after the PPA and write-off period, which could be used to lower the future costs for the country's electrical system.

The borders of the resulting price band correspond mainly to different Direct Normal Irradiation (DNI) in kWh/m²/y and, to certain extend, to country's specific conditions as the other main variables reflect standard market rules. No public support of any type (grants, subsidized loans or guaranties, etc.) has been taken into account when calculating these curves.

If an escalation factor of the PPA with inflation or oil index had been taken into account, the harmonized values for the current project would have been significantly lower, as well as the cost reduction curves. Longer PPA periods or loan terms would have an important impact on the required PPA or FiT for a given project.

Looking at these figures and, once again, comparing them with the expected generation costs of Wind and PV, it is necessary to take also into account the value of dispatchability. A recent study, The DOE Sun Shot Initiative, from the U.S. Department of Energy (DOE) gave an estimate in the range of 4 c$/kWh as additional value for dispatchability, as the generation can be shifted to hours with higher energy prices, avoiding curtailment, etc. Other studies from NREL and DLR showed the added value of the electricity from STE plants with storage as well.

Another relevant observation when comparing installation costs is the fact that dispatchable plants will require significantly less backup systems. If STE plants are chosen as the base option for enlarging the generation park in a given country, *Dispatchability value, escalation linked to oil prices and golden end after PPA period position STE as an attractive choice for the countries in the Sun Belt.*

the investment required for doubling the capacity installed in the next ten years will be lower than using intermittent technologies plus the necessary complementary fossil fuel plants.

The technology does not limit the lifetime of STE plants to 20 years, the typical debt period in financing. The Californian SEGS plants have proven that STE plants can last longer than 40 years: they have been in operation since the middle 1980's in California. This provides an interesting mechanism for policy makers who can take into account the "golden end" of the STE plants when defining a support program. It could either provide an additional incentive to the investor or could be used to reduce electricity costs in a country in the future, as only O&M costs will apply after the determination of the PPA or FiT periods.

The cost reduction curves which have been shown in the picture on page 11 apply to STE technologies in general and not to any one of the current types in particular. The cost figures for a given year will correspond to the cheapest concept at that time, which could also be site dependent. However, in the next few years, it is not likely that one specific technology will show up as "the" winning option, even though improvement of components or new working fluids might change the result in the future. Integrating solar fields into conventional existing plants will show even lower prices and may provide an excellent opportunity in specific places.

The new technology options and plant configurations under study (i.e. towers with heliostats or linear Fresnel reflectors) shall either increase the efficiency of the overall process or reduce the installation costs. The current predominant technology, parabolic troughs, is also subject to research to increment the efficiency by using different fluids allowing higher working temperatures.

Improvements on specific component materials and manufacturing will also help in reducing costs. The main objectives are to increase efficiency and to reduce costs while, at the same time, remaining fully environmentally friendly.

The scaling-up of plant size and the increase of installed capacity worldwide will significantly contribute to lowering costs as well. Therefore, it is reasonable to say that, if the 30 GW threshold is reached by 2020, STE power plants would feed dispatchable and reliable electricity to the grid at 10 –12 c€/kWh, depending on the available irradiation. This would make the STE technology totally competitive with conventional power generation in the medium term, considering realistic scenarios of increases in fossil fuel price and CO_2 emission rights.

New financing approaches could be considered to reinforce the choice for STE plants instead of conventional plants. In addition, escalation factors on the tariffs related to the fossil fuel prices will certainly show clearly the advantages of STE plants in comparison with technologies that significant price increases are expected.

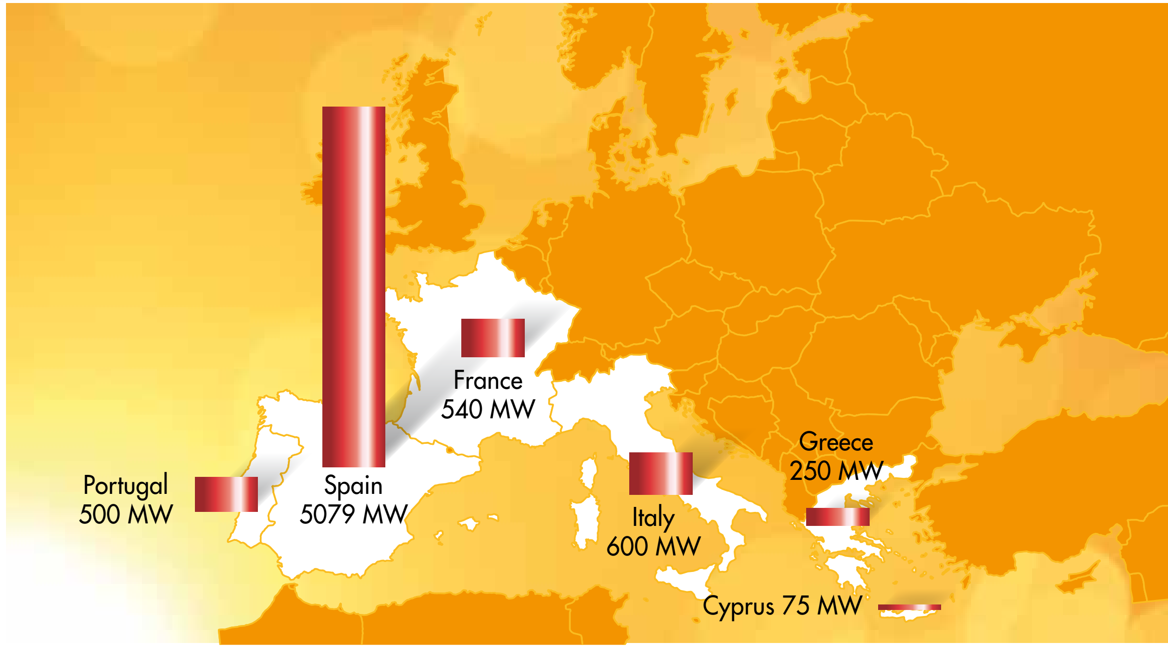
THE GREAT OPPORTUNITY FOR EUROPE

Energy is the backbone which supports the progress of countries and regions. Different energy models may have an enormous impact on the socio-economic well-being and on the environment.

In their National Renewable Energy Action Plans (NREAP), EU Member States have already announced a renewable (STE) energy capacity of approximately 7,000 MW in Europe by 2020 (see figure below).

Reducing the vulnerability of European economy to fuels shortages and to the impacts of uncontrolled rise of fuel prices, as well as the vulnerability to currency change uncertainty, is a top priority.

Europe has enough renewable energy resources to become energy independent and CO_2-emission-free in the long term and to profit from the internal economic impact of the decision to move towards a renewable energy based electricity generation system. Extending the interconnected region towards MENA could further reduce costs and create favourable win-win situations in energy supply and socioeconomic development for the whole EUMENA region.



An energy system based on Solar and Wind with a certain contribution of Hydro and Biomass along with the Supergrid is feasible and economically viable from a wide perspective. Implementing this vision will reinforce the global economic position of Europe from now on, for decades to come.

PV plus firm and dispatchable STE plants including storage and hybridization will be seasonally complementary with On- and Offshore Wind. Biomass and Hydro would contribute to further stabilize the supply.

The supergrid is the necessary infrastructure to make it happen. Electrical and biofuel transportation system plus energy efficiency and the use of other renewable technologies for residential and industrial heat demands will close the circle of an independent, sustainable and economic European energy model.

In order to move forward, a stable regulatory framework in the European countries is urgently needed. "Stop and Go" approaches with plenty of uncertainties for investors are not the right way to proceed. The commitment to the 2020 goals and the control role of European Commission is essential to make the indicative trends of STE deployment in different Member States happen.

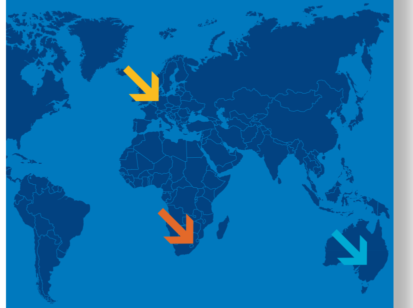
Local economy empowering, dispatchability and the potential for cost reduction will earn for STE a relevant share in the future CO_2-free electricity generation mix worldwide.

Therefore, STE represents a major opportunity for Europe to meet its internal development and social goals to overcome the economic crisis, and to strengthen the international deployment of our Industry.

The following suggestions are addressed to policy makers at both European Union and Member State levels:

- Stable regulatory frameworks, with no room for retroactive measures.
- Assuring the internal markets as committed by the Southern European Member States to the Commission in their respective NREAPs submitted to the Commission.
- Continuous support to R&D projects and to first-of-its-kind commercial plants.
- Implementation of new financing instruments to reduce the financing cost, including risk sharing mechanisms.
- New operative mechanisms to make the statistical transfers among Member States and the physical imports from Northern African countries according to the RES Directive possible. The creation of a joint off-taker, which ESTELA is advocating, could be the key element for this development.
- Reinforcement of the electrical interconnections between Member States and promotion of the European Supergrid as well as new physical interconnections with MENA countries.

STELA WORLD
World Solar Thermal Electricity Association



ESTELA

SASTELA

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ABOUT ESTELA

ESTELA is a non-profit association, of which the main objectives are: promoting, supporting and representing the solar thermal electricity sector and its Members. ESTELA is a service oriented association assisting public bodies and institutions, elaborating studies, disseminating best practices in solar thermal electricity generation and creating opinion. Today ESTELA represents more than 200 companies and institutions, including the national associations Protermosolar (Spain), ANEST (Italy) and SER (France). ESTELA has consolidated its position and has been taken as a reference for other industry associations such as SASTELA (South Africa) and AUSTELA (Australia). These industry associations – ESTELA, AUSTELA and SASTELA – coming from three different continents have created the World Solar Thermal Electricity Association, STELA World, in June 2012.

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