Delivering on Earth's *Solar Potential*

Concentrating Solar Thermal Power as a solution to the world's energy challenges

September 2009

THE CLIMATE GROUP

PRICEWATERHOUSECOOPERS

Front cover | Solucar PS10 and PS20, Abengoa Solar

> "What if you could provide the world with an endless supply of virtually carbon free electricity; ensure a constant source of drinkable water to the world's most vulnerable areas; avert some of the world's future humanitarian crises; and save billions of dollars in the process? Concentrating Solar Thermal Power (CSP) proponents say there is no 'could' about it - it's more a case of 'can'.
>
> CNN, 12 November 2007"

Contents

Solar Potential

so·lar / sōlər/ adj.

- of, relating to, or determined by the sun
- solar radiation: relating to or denoting energy derived from the sun's rays

po·ten·tial (p-tnshl) / adj.

- Capable of being but not yet in existence
- Having possibility, capability, or power

Solar Potential is the name that has been given to the collaboration between The Climate Group and PricewaterhouseCoopers LLP (PwC) to research and communicate the opportunity to accelerate the development of a Super Grid, and the uptake of renewable sources of electricity, in particular Concentrating Solar Thermal Power (CSP), globally as a direct means of tackling Climate Change and energy security.

Introduction

Numerous studies over the past few years have confirmed that substantial climate change is now unavoidable and that it poses an immense risk both to mankind's everyday lives and the world around us. Governments, business and NGO's have come together and begun to coordinate their efforts to address this challenge. New policies and initiatives have been announced around the world and in the coming months, attention will be focussed on the COP15[1] discussions in Copenhagen, where governments will commit themselves, in a variety of ways, to addressing the causes and effects of climate change over the coming years.

One worry however, is that despite good intentions and the announcement of ever impressive and long term goals, the number of practical and realistic steps agreed to move the world forward in the short term may be limited. One area where there is large potential for short term progress is in relation to energy production. With energy generation being responsible for the majority of man made CO_2 emissions today, the way in which the world obtains its energy should be at the forefront of how we begin to address the climate change challenge.

PwC's view is that the world needs to quickly identify and promote those scalable renewable energy solutions that can cut global greenhouse gas (GHG) emissions and help move us to a low carbon world. As part of it's Solar Potential initiative with The Climate Group, this publication provides an introduction to one of these technologies, concentrating Solar Thermal Power or CSP, and the role that it can play across Europe, the Middle East and North Africa.

This booklet also begins to outline the questions that should be asked and the steps that should be taken at a technology and a policy level in the next few months to ensure that we achieve a secure and low carbon energy future in the coming years. Government support focussed on the right renewable technologies, combined with appropriate policies, outreach and advocacy has the potential to achieve a step change in the provision of energy and the action to tackle climate change.

If you are interested in learning more or becoming involved in this work, then please get in touch with us via the key contact names provided at the end of this booklet. We look forward to the opportunity to engage with you in this important challenge.

1. The United Nations Framework Convention on Climate Change will hold it's 15th session of the Conference of Parties in Copenhagen in December 2009.

Executive summary

The challenge

The impact of climate change will be substantial. The world is also increasingly beginning to realise that our existing energy infrastructure is incapable of meeting the increasing demands that we will place upon it in the coming years. With both these issues intrinsically linked, there is an urgent need to take action, even more so given that progress to date has been slow and limited in its impact.

The opportunity

The world now needs to identify and promote the solutions that can immediately cut global GHG emissions and energy security issues.

This presents governments and businesses with all opportunity to create renewable energy visions and roadmaps that reach across borders, technologies and generations and deliver in the years to come.

The solution

As part of a multi-faceted approach, CSP can play a key role in addressing this challenge. It is a technology that has been in existence for over a 125 years yet, it has been below the radar for most governments and major global businesses to date mainly because of its relatively high short term costs.

Next steps

There is an immediate need to develop and deliver a regional renewables roadmap. This will help to create more stable market conditions and advance the benefits that renewable energy can bring. The certainty created by such a roadmap will encourage greater investment in a range of CSP projects and ongoing R&D. Continued deployment of CSP technology will enable the levelised costs of electricity to drop. With the right market and regulatory structures in place, host countries will be in a position to enjoy some of the social and economic benefits that the introduction of CSP and other renewable technologies can bring.

Why CSP?

- CSP produces clean electricity with no hazardous operational waste by-products
- It can supply electricity on demand with storage and co-firing options possible
- It has the potential to supply electricity over large distances when combined with High Voltage Direct Current (HVDC) infrastructure
- It is based on proven technologies, many of which are available now on a commercial scale
- It can directly and significantly contribute to a reduction in GHG emissions with like for like displacement of fossil fuel alternatives
- It can deliver considerable social benefits in developing and economically disadvantaged areas of the world
- CSP requires less land than hydro or photovoltaic (PV) to generate electricity
- It has the potential to support the desalination of sea water
- It is not dependent on any scarce natural resources

Executive summary

How CSP works

CSP technology uses mirrors or solar collectors to track the sun and focus light onto a central point containing a heat transfer fluid. This fluid then passes through a steam generator where the heat boils water to create superheated steam. The steam drives a turbine, which drives a generator and this feeds electricity into a transmission grid.

Storage of solar heat is also possible, and the use of gas or biofuels as a back up source of heat means that electricity may be generated at night and on cloudy days. With connection to a HVDC transmission grid, it is then possible to transmit the electricity over large distances with minimal loss of power.

> “Within 45 seconds, the surface of the Earth receives enough solar energy to fully meet the world’s entire energy needs for that day.[2]”

Key Benefits for Europe

Clean and Secure Energy

- GHG emission reductions
- Opportunity to create a more diversified source of electricity for Europe
- Production of “clean” electricity that meets the renewable directive targets
- Possibility of generating value through Certified Emissions Reductions (CERs)[3]

Energy Market Development

- Driving the development of a coherent energy policy across Europe
- Increased political and commercial cooperation across EUMENA

Economic Benefits

- Potential for stable and lower cost electricity over time with increasing scale of production
- Economic development/innovation

Key Benefits for the Middle East and North Africa

Access to Resources

- Domestic provision of electricity to rural areas
- Improved grid infrastructure
- Increased energy security and independence
- Desalination of seawater and the provision of freshwater to areas affected by water scarcity

Economic Regeneration

- Export earnings from the sale of ‘clean’ electricity to Europe
- Availability of water and funds to support horticulture
- New investment and development opportunities
- Job creation during the construction and operation of the sites

Social Benefits

- Reduction in emigration as a result of increased local jobs and earning potential
- Opportunity for transport and mobility
- Increased standards of living
- Increase in education and expertise

2. Trans-Mediterranean Renewable Energy Cooperation (TREC) is now represented by the Desertec Foundation: www.desertec.org
3. CERs are tradable carbon credits generated from Clean Development Mechanism projects under the guidance of the Kyoto Protocol

Our global challenges

> Our climate is changing, and we are faced with many years of continuing unavoidable change. Even if we make a significant reduction in greenhouse gas emissions tomorrow, the lag in the climate system means that we will need to cope with a changing climate for the next 40 plus years, due to emissions we have already put into the atmosphere.[4]

The environmental and economic challenges

Many reports have been issued over the past decade highlighting the increasing concentrations of atmospheric GHGs such as CO_2 and the impact that these have on global warming. When this is combined with ongoing natural resource depletion, human population increase and migration and biodiversity loss around the world, we could be facing a bleak future.

To enable us to understand these developments and develop a coherent response, scientists and researchers have identified a number of mega-trends through which the resultant impacts will be felt. These range from likely shortages of water and energy, to changes in agriculture and biodiversity around the world. The global response to these challenges to date has been largely inconsistent with the scale of the problem. Efforts have primarily been focussed on selective mitigation measures with very little work done by way of adaptation, particularly in the developing countries that are likely to be most affected by climate change.

During 2008 and 2009, the world introduced a further self inflicted crisis – the economic crisis. This continues to impact the global economy today and has the potential to limit and distract the attention of the world at COP15, in December 2009, from taking steps to address the more serious and long term climate change issues.

In 2009, Lord Stern outlined that the economic crisis will be shorter term and less profound than climate change or poverty.[5] Our response to this economic crisis has the potential to play a very important role in determining our ultimate success in addressing the impacts of climate change. If the world were to exclude the move to a low carbon economy from the response to the economic crisis, we could instead be sowing the seeds for the next, potentially larger financial crisis.

With man-made GHG emissions acknowledged to be the primary cause of climate change and with the majority of these emissions resulting from the combustion of fossil fuels for energy generation[6], there is a clear opportunity to link a response to the economic crisis with an active programme of investment in low carbon and renewable energy opportunities.

4. Firth, J and Colley, M, 'The Adaptation Tipping Point: Are UK Businesses Climate Proof?' Acclimatise and UKCIP, Oxford (2006)
5. Stern, N., "A Blueprint for a Safer Planet: How to manage Climate Change and Create a New Era of Progress and Prosperity", The Bodley Head, London (2009)
6. Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report (2007)

Our global challenges

The energy challenges

- **Demand:** Supply challenges will result from continued population growth and economic development. Some estimates put global demand increases at 50% by 2050. Such an increase cannot be met by existing and planned generation and transmission infrastructure investments.
- **Transmission:** Much of Europe's existing transmission infrastructure will struggle to cope with the expected increase in future energy demands. Whilst some work has been completed to increase capacity and upgrade transmission lines to HVDC technology, substantial further work remains.
- **Emissions:** GHG emission reduction targets will restrict the new build and ongoing use of fossil fuel power stations. Unless a higher carbon price is accepted, alternative renewable energy sources represent the only way of producing energy and still meeting these targets.
- **Strategy:** Continuing price volatility, concerns about security of fossil fuel supply and increasing energy demands, have forced governments to reconsider both their source of supply and their overall energy policy.

Setting global targets

Governments have come together over the past decades to agree measures aimed at reducing emissions of GHG. The Kyoto Protocol required ratifying countries to curb emissions by 5.2% (compared to their 1990 level) by 2012 and work is now underway to define the post 2012 regime. In December 2009, governments will again assemble, this time at COP15 in Copenhagen, in an effort to agree a new set of post-Kyoto targets and measures. The endorsement of secondary targets by world leaders will play a key part in determining whether a concerted response is possible, but the risk remains that progress will again be slower than originally envisaged.

> "Europe needs to work harder to diversify its sources of energy, something it must do anyway if it is to meet its ambitious climate change targets…a fully liberalised energy market with better linkages between countries, offers Europe not only a more efficient energy future, but also a more secure one.[7]"

7. The Economist, 10th January 2009

Our global challenges

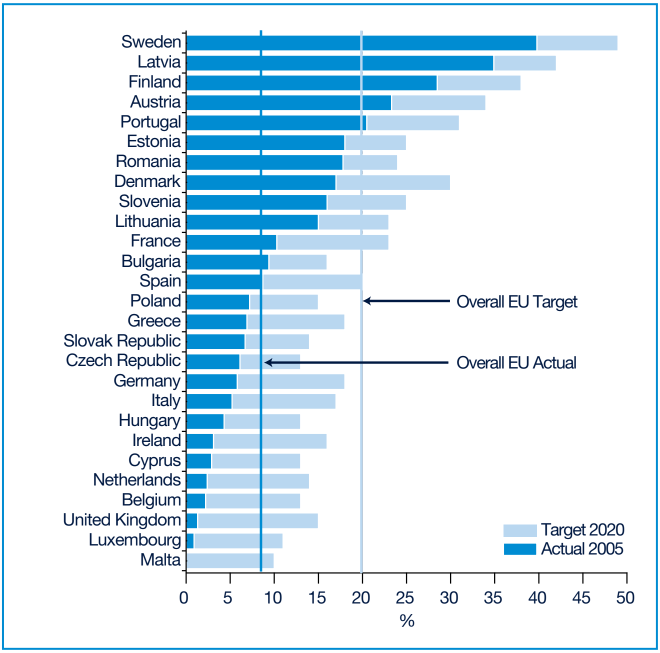
The national policy response

At a national level, several countries have adopted ambitious emission reduction targets. India and Australia have recently announced plans to produce 20% of their energy from renewable sources by 2020. These activities mirror those adopted by the US, where President Obama has committed to stricter targets and made significant investment available for the development of renewables, clean technology and Smart Grids.

In the EU, governments such as the UK have set targets to reduce national GHG emissions by at least 10% and 20% (compared to 1990 levels) by 2010 and 2020, and EU MEPs recently voted in favour of long term reduction targets of 60 - 80% by 2050. The recent amendments to the Renewables Directive[8] provides good support for cross border renewable projects through the inclusion of a co-operation mechanism which allows Member States to meet their renewables targets from the import of electricity from other countries.

Other areas of focus have been the restructuring of the EC framework regarding the taxation of energy generation to allow partial exemptions or reductions in the taxation of renewable sources. The hope is that this legislation will act as a driver for industry and consumers to become more energy efficient whilst also encouraging the use of more electricity from renewable sources. However, as shown below, more can and should be done to ensure that progress is made by countries to achieve their targets.

Share of energy consumption from renewable sources[9]



It is clear that at present, very few countries are in a position to come close to achieving their EU Renewables Directive reduction targets. Further government and business action, will be required to enable these targets to be met.

8. The Directive on Electricity Production From Renewable Energy Sources (2001/77/EC), as amended (2009/28/EC) is referred to as the Renewables Directive
9. Renewables 2007, Global Status Report, REN21 (2008)

The role of renewable energy technologies

The role of renewable energy technologies

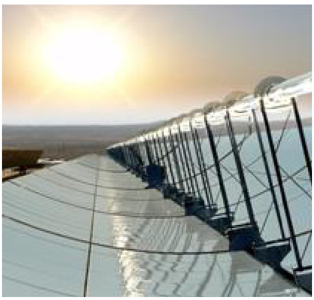
There is no doubt that renewable sources of energy can play a major part in the efforts by countries to address climate change. What is needed now is well designed policy and legislative proposals from governments. These will encourage changes in behaviour in industry, amongst consumers and encourage a greater demand for renewables.

People often ask which forms of renewables have the potential to play the largest role. The past few years have already seen investment in a range of renewable technologies. Depending on the area of government focus and the availability of natural resources, wind, biomass, geothermal, tidal, hydro and solar have already begun to make inroads in commercial electricity supply in a number of countries around the world.

However, governments also need to be aware that the energy industry currently faces an internal crisis which will only be exacerbated with the introduction of further regulations and restrictions. National and regional plans to address climate change will therefore need to consider, in detail, not only the sources and amounts of GHG emission reductions that will be required, but also the structural changes that will need to be put into place across industries to support these targets.

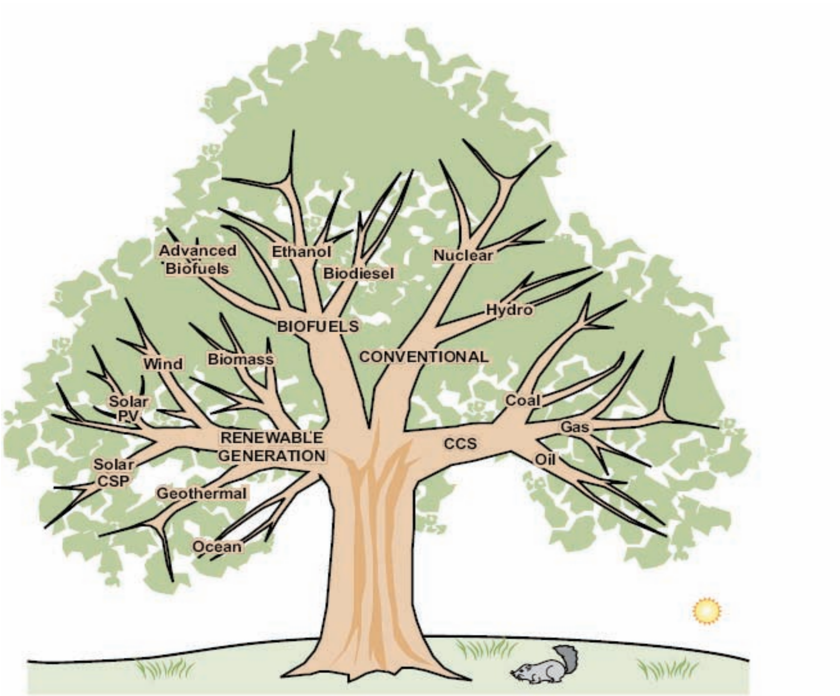
The development of an ambitious vision for the future of the renewable energy sector will encourage the large scale deployment of a number of both established and developing technologies. It will also and allow a more coordinated and joined up approach to be taken in the development of policy and legislative measures.

The good news is that with renewable energy technologies promising delivery of energy in a low carbon way, the energy industry has the opportunity to transform itself from part of the climate change problem to becoming a key player in developing a lasting solution to climate change and energy security.



The role of renewable energy technologies

The clean energy tree[10]



With higher fossil fuel prices and increasing concerns over energy security likely in the coming years, we expect governments to further encourage the development of renewable energy for electricity production.

The key issues are for:

(i) the energy industry to be able to incorporate these new renewable sources of energy effectively into its existing infrastructure, and

(ii) governments to work together to develop an appropriate policy framework to support the development of renewable technologies. This should reflect regional energy resources and demands, and minimise the desire for individual countries to achieve short term domestic gains.

10.Crossing the Divide: The Future of Clean Energy, IHS Cambridge Energy Research Associates (2007)

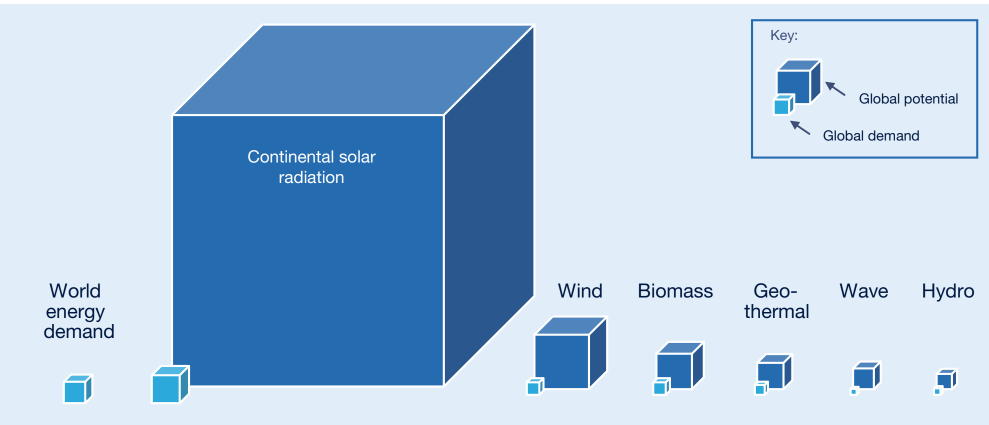
The time is right for CSP

Positioning CSP to help meet our energy needs

When examining the commercially available renewable energy options today, it is easy to see that solar is far more abundant and has greater potential than all other forms of renewable energy. Most forms of renewable energy are limited in their quantity – solar is not. In addition, as a natural resource, the sun's energy is more abundant and geographically spread compared to other renewable resources. The challenge then (taking into account a number of factors including cost, technology risk etc), is to identify which type of solar technology is best placed to harness this source of energy to produce electricity on a commercial scale.

One form of solar technology, photovoltaic (PV) panels, converts sunlight directly into electricity. Another form, CSP, uses the sun's heat to produce steam that then drives a traditional turbine to produce electricity. Each approach has its advantages and disadvantages. Our view is that CSP is better placed to play a globally dominant role in the electricity sector. This is based on several sources that have considered a number of factors including existing and expected technology developments, operational track record and trends in the levelised cost of electricity.

Renewable energy technically available today exceeds global demand[11]



The International Energy Agency (IEA) forecasts that CSP will (with biomass and geothermal sources) contribute up to 30% of global electricity generation from renewable sources by 2030.[12] A number of governments around the world have recognised the potential of solar energy and in the last 6 months alone, substantial commitments have been made to increase solar electricity production. Countries where incentives have been in place for a while and commercial CSP plants are already in operation are expected to show further large increases in production, e.g. Spain and the US.

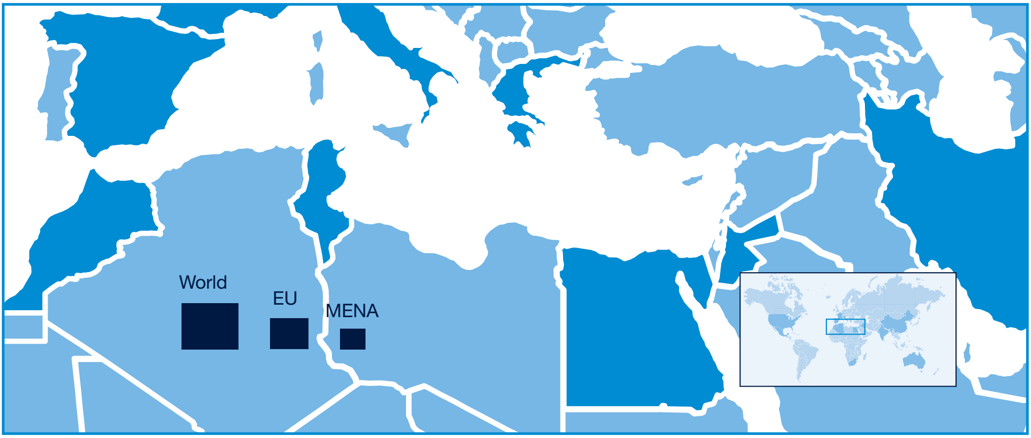
11. German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU)
12. International Energy Agency, World Energy Outlook (2008)

The time is right for CSP

Recent headlines

Australia plans to build the world's largest solar power station with an output of 1GW in a A$1.4bn project.	China launches a green power revolution to catch up with the West. $30bn is to be invested in low carbon projects, including solar, to achieve 20% renewables by 2020.	India to invest $22bn in a bid to become world leaders in solar. The government releases details of it's solar plan in August 2009.
Germany 12 companies signed a Memorandum of Understanding in Munich to establish the Desertec Industrial Initiative (DII). The objective of this $555bn initiative is to analyse and develop the technical, economic, political, social and ecological framework for carbon-free power generation in the deserts of North Africa.		US Two solar thermal projects are awarded to a CSP company totalling 2.6GW.

Land use



The diagram above indicates the size of the area of desert that theoretically would be sufficient for CSP plants to generate as much electricity as is currently consumed annually by the world, Europe (EU-25) and Middle East and North Africa (MENA) respectively.[2] Less than 1% of the area of the world's deserts, if covered with CSP plants, could produce as much electricity as the world currently uses.

World:	300 km x 300 km	(90,000 km^2)
EU:	127 km × 127 km	(16,129 km^2)
MENA:	55 km × 55 km	(3,025 km^2)

The time is right for CSP

Key benefits of CSP

Low carbon	CSP produces clean electricity and utilises the largest, technically accessible source of energy: the sun.
Low operating costs and increased energy security	Large-scale CSP offers stable and decreasing costs of electricity generation. Already competitive against fossil fuels and nuclear power when environmental costs and other externalities are properly accounted for, it has the potential to be much cheaper than established sources of power.
Proven technology	There are a range of technologies that have evolved over the years. Some of these are proven and have been operating on a commercial scale since the early 1980s, and some are still in development. Each technology offers increased efficiency and capacity with increases in scale.
Dispatchability	With integrated storage options and / or co-firing with fossil fuels, CSP technologies have the ability to provide baseload power on demand, something that other forms of renewable technology currently cannot deliver.
Desalination	Sustainable and carbon free desalination of seawater is possible, with the water produced then being used for human consumption and agriculture.

> "The sun's potential for power generation eclipses that of all other renewable energy sources… Every hour it floods the earth with a deluge of thermal energy equal to 21 billion tons of coal. The enormous output of solar energy is almost impossible to conceive… But for now solar barely registers in the world's energy portfolio accounting for only a small fraction of total electrical output.[13]"

13. National Geographic Magazine, September 2009

The time is right for CSP

Characteristics, strengths and weaknesses of some of the most common CSP technologies

Type of Technology				
	Parabolic Trough	Fresnel	Tower	Dish
Description	Solar energy is concentrated by parabolic mirrors onto oil (or other heat transfer medium) filled pipes or collectors. The heated medium is then used to generate steam and drive a steam turbine generator.	Solar energy is concentrated by several rows of flat mirrors onto a water filled collector pipe. This water is vaporised and drives a steam turbine generator.	Solar energy is concentrated onto a central tower by an array of moveable, flat mirrors (heliostats). The heat energy generated is used to produce steam which in turn drives a turbine generator.	Dish systems utilise parabolic-shaped mirrors or concentrators to reflect solar radiation onto a receiver mounted at the focal point of the concentrator. The two-axis tracking receivers typically include a heat engine for power conversion.
Advantages	Solar troughs are the most proven of solar thermal technologies and the use of single axis tracking reduces the capex involved and allows for less technical installation.	Lower capital costs due to the use of flat mirrors, shared collectors and single axis sun tracking. Their smaller size also allows for a higher generation density than other technologies.	Solar towers result in the highest heat levels of the CSP technologies, allowing for efficient energy conversion.	These systems have very high solar to electric conversion efficiencies and so have the potential to become sources of inexpensive energy. The modularity of the dish/ engine also means that they can be employed individually or grouped according to application.
Disadvantages	Much like heliostats, parabolic mirrors are costly to manufacture. The temperatures generated are relatively low compared to other technologies resulting in less efficient conversion of energy.	This technology is not commercially proven with mostly prototypes and pilot projects in existence. The partial blocking of solar radiation also leads to reduced energy capture.	Solar towers are a relatively new technology with a high capex due to the cost of heliostats and complex nature of the dual axis controls which govern their orientation.	This technology is relatively unproven on a commercial scale. It also has a relatively high capex due to the cost of the systems and the complex nature of the dual axis controls.
Technical information[14]	C: 70-90 η: 12%–14% Power: 14-19	C: 60-120 η: 10%–12% Power: 19-28	C: 500-1000 η: 10%–15% Power: 9-14	C: 300-4000 η: 14%–18% Power: 9-14

14. C = Concentration ratio. Fraunhofer ISE (2009)
η = annual efficiency. Fraunhofer ISE (2009)
Power = W/m^2. Sustainable Energy Without The Hot Air, D Mackay (2009)

The time is right for CSP

Positioning CSP to help address GHG emissions

CSP can also help directly with efforts to reduce CO_2 emissions. For example, research has suggested that each single square kilometre of desert can potentially generate 50MWhrs of electricity and avoid 200,000 tons of CO_2 emissions. Estimates have been made that indicate that if it were deployed globally, CSP electricity could avoid up to 35Mt/year of CO_2 by 2020 and 130Mt/year of CO_2 by 2030.[15]

Introduction to HVDC and Super Grids

High Voltage Direct Current (HVDC) technology has been in use for many years for transmission of electricity over large distances via either terrestrial, subterranean and submarine power cables. In countries such as South Africa, China, America, Canada, Brazil and the Congo, HVDC cables are already being used to transmit electricity over 1,000km+ distances. In some cases, these have been in place since the 1950's.

HVDC cables are preferred over traditional High Voltage Alternating Current (HVAC) lines because less physical hardware is needed, less land area is required and the power losses when transmitting electricity over larger distances are smaller (2.5% over 1000km for DC cables compared to 6% for AC.[16] Despite this, most grid networks still rely on AC lines.

Combining this HVDC technology with the concept of a Super Grid or SuperSmart Grid[17], would allow electricity from renewable sources in North Africa to be transmitted around the Mediterranean and across Europe with minimal loss of power. Through projects like MedRing[18] and individual EU country initiatives, work is already underway today to begin the development of a Europe-wide HVDC grid.

15. An overview of CSP in Europe and MENA, CSP Today (2008)
16. Trans-Mediterranean Interconnection for Concentrating Solar Power, DLR (2006)
17. European Climate Forum, see www.supersmartgrid.net
18. MedRing is an initative to create a synchronous transmission link connecting the countries surrounding the Mediterranean Sea

The time is right for CSP

Positioning governments to support the uptake of CSP

The idea of generating electricity in high solar energy locations and then transmitting it to centres of demand is not new. A number of initiatives have developed and promoted these ideas for over 10 years. One of these, the Trans-Mediterranean Renewable Energy Cooperation (TREC)[2], has, looked to gain interest in a concept known as **Desertec**.[19] Numerous studies and papers have been developed promoting this idea and detailing the opportunities that such a deployment of CSP and Super Grid could offer. One study concluded that it could realistically provide 15% of Europe's electricity needs by 2050.[16]

In addition to substantial capital investments, such ambitious concepts require significant political will to move forward. Appropriate legislation and regulation also needs to be devised at national and regional levels. One encouraging development has been the announcement of a number of government and business initiatives during 2008 and 2009 to explicitly promote and progress a Desertec type concept. The Mediterranean Solar Plan announced by the French presidency of the EU in July 2008 and the Desertec Industrial Initiative announced by a consortium of companies in July 2009, both have substantial government and business commitment behind them that will help ensure they remain high on the agenda for politicians and industry.

Our view is that recognition with these activities underway and an increased of the need to address climate change, the time is right for governments and business to demonstrate leadership by actively focussing on, supporting and accelerating the large scale rollout of renewables (in particular CSP) and Super Grids. This should also be seen as an unparalleled opportunity for building stronger ties and encouraging economic and social development in less developed countries.

Engaging with governments to support the uptake of CSP

Specific points of engagement during 2009 and 2010 to progress a wider CSP / Super Grid initiative include:

(a) Swedish and Spanish EU Presidencies. The current and next presidencies of the EU, namely Sweden (Jul-Dec 2009) and Spain (Jan-Jun 2010) are well placed to provide political support for action on renewables.

(b) Strategic Energy Technology (SET) plan. The EU embarked in 2007 on a Strategic Energy Technology plan process for EU co-operation on research and to set the future direction of investment in energy infrastructure and transmission. A SET-plan conference will be held in October 2009 in Stockholm.

(c) Copenhagen. The COP15 meeting in Copenhagen in December 2009 provides a unique opportunity to secure support for low carbon energy investment, building on the recent G8 commitment to reduce emissions by 80%.

(d) Energy stimulus package. The EU's energy stimulus package includes €3.98billion for energy infrastructure investment. Several EU Member States have announced similar packages.

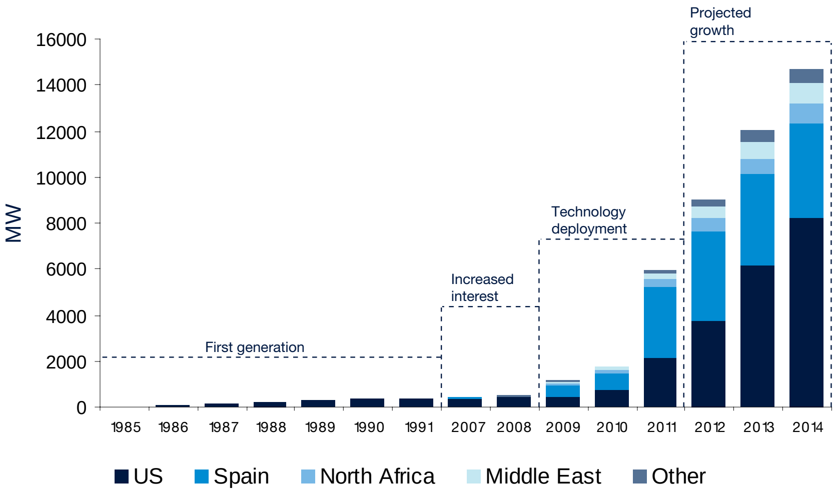
(e) Interest in a connected renewable strategy for the EUMENA region. Based on the work of Desertec and others, there is currently a high level of interest from government and across industry to explore the potential to connect renewable resource-rich regions with high-demand regions within EUMENA.

19. The Desertec concept describes an integrated renewable energy network across Europe, North Africa and the Middle East. Renewable technologies will be located in the geography they are best suited to, and will be connected by a cross-continent Super Grid. The Desertec Industrial Initiative (DII) and the Desertec Foundation were established in 2009 to promote this concept.

Facilitating the growth of CSP in a low carbon future

PricewaterhouseCoopers and The Climate Group believe that CSP is one of a few currently available low carbon technologies which can be considered for a globally dominant role in the electricity sector over the next 40 years. It can deliver energy security and help to directly address GHG emissions in both developed and developing countries. This view is shared by others, and recently published information has predicted that installed CSP capacity is poised for tremendous growth.

Historic and projected global CSP pipeline[20]



A number of steps need to be completed to achieve the establishment of CSP and Super Grid capacity:

1. A new vision. A robust, up-to-date assessment of the potential carbon and economic benefits for key EUMENA regions (focusing both on energy net exporter and net importer regions) is required.

2. A recommended policy road map to achieve the necessary commitments and financing mechanisms for renewable and Super Grid implementation will be needed to provide politicians with the necessary detail to take this ambition forward in a coordinated manner.

3. A ‘coalition of the willing’. A targeted stakeholder outreach programme is needed to build support for this new vision. Delivering a Desertec type initiative will require a coalition of utilities, grid operators, technology providers, investors and regional governments to work closely with existing initiatives and programmes.

20. Global Concentrated Solar Power Markets and Strategies 2009-2020, Emergency Energy Research (2009)

Facilitating the growth of CSP in a low carbon future

In the short term, engagement with government and industry will also need to consider a number of structural challenges. These include, but are not limited to, the following:

Political activities

There is a need for political will to create the right legal and financial framework to govern the actions and activities of a large scale CSP programme. This would also include further regional bilateral agreements to ensure widespread political support.

Market structure

Creating a single market for electricity throughout EUMENA or Europe, and developing a reliable framework for the market introduction of renewable energy technologies.

It is important that a proper price is paid for emissions of CO_2, and that a reliable carbon market is established that encourages investment in alternatives to fossil fuels. This includes removing overt or hidden subsidies for non-renewable sources of energy.

Renewables

In Europe, political and business support will be required for the implementation of the EU Renewables Directive. This will ensure that there is continued focus on **how** Europe will deliver on its commitments to promote renewable energy and **where** it should be coupled with further national and EU wide regulation to promote renewable energy.

Certainty

Providing the right framework of incentives will be important. This includes long term power purchasing guarantees and removing government imposed restrictions on the total renewable capacity that can qualify for subsidies and feed in tariffs (FITs). Countries that provide the most certainty will attract the most investment and/or supplies of electricity from CSP plants.

Financing and finance structures

The development of greater grid connectivity between Europe and North Africa will require large investments within an adequate financial framework. This will require careful governance, management and support from a range of stakeholders.

Costs of energy

Electricity production costs will play a key role in determining whether CSP is adopted on a large scale. Convergence of costs with other renewable sources and fossil fuels is expected in the coming years and will need to be supported by continued technological innovation, decreasing component costs, economies of scale and innovative financing arrangements.

Infrastructure

The financing and development of transmission infrastruture is critical to the implementation of CSP. Once in place this will also promote economic development in North Africa, and support the growth of other renewable sources of electricity.

Utilities

Utilities companies will need to engage with governments and businesses in the renewables debate, consider changes to their business models, support renewable energy pilot projects and do more to inform their customers about the costs and benefits of renewable energy.

Environmental and social considerations

Environmental and social impacts must be evaluated carefully in order to avoid harmful results. Prior to the commencement of a project environmental impacts from both CSP plants and HVDC transmission lines need to be considered and addressed to avoid environmental harm and possible public resistance to future projects.

A roadmap for success

Developing a policy roadmap

In our view, the development of a policy road map to achieve the necessary commitments and financing mechanisms for renewable and Super Grid implementation should at a minimum consider the following questions:

What is the current status of:	What is the opportunity / vision?	What are the challenges to achieving the vision and how might these be overcome?
• The renewable energy policy landscape at a local, national and regional level • The renewable energy market structure • The involvement of governments, markets, regulators and utilities to date in supporting large scale renewables e.g. FITs, tax incentives, power purchase agreements (European support mechanisms vs. Member State mechanisms) • The role of taxation as a key policy instrument; has it been an enabler or inhibitor? • The perception of the public, business and government to the risks and challenges of large scale renewables	• What is the desired outcome for large scale renewable generation? • What are the policy implementation options for enabling large scale renewable generation across EUMENA? How could the current regime be improved? • What are the key economic, social, development, environmental, carbon and other opportunities and benefits to large scale renewables? • Other possible applications and opportunities that arise from large scale renewable technologies, e.g. industrialisation in developing countries • Indirect benefits and “ripple” effects of a renewable energy environment • Security and risk issues	• What is currently holding back the development of harmonised and integrated large scale renewables generation from an energy policy viewpoint? • What policy mechanisms are required to allow large scale renewables generation to progress, on a local, national and regional level? • Where are changes to the market and operational structure required (including carbon markets)? • What role could tax play, and how should this be structured on an intergovernmental scale? • What is the need for new organisations to manage a integrated renewables generation programme? • How valid are the perceptions of the public, business, and governments to the risks and challenges of large scale renewables? • What is the best approach to challenging these perceptions when they are contentious? • What is the best approach to stakeholder communication / engagement over the longer term?

A roadmap for success

The policy roadmap should also consider the appropriate “push” and “pull” mechanisms, their success/failure to date and their impact across a broad range of renewables. Direct regulatory incentives such as feed-in tariffs “push” a new technology into the market, while “pull” policies apply a more adverse cost structure to existing technologies.[21]

“Push” Policy Options

- Feed-in tariffs
- Investment tax credit
- Accelerated depreciation
- Loan guarantees
- Sales/property tax waiver/reduction
- Concessionary finance
- Lower import tariffs
- Export credit
- R&D support

“Pull” Policy Options

- Carbon price
- Carbon offset mechanism
- Renewable portfolio standard
- Removal of incentives encouraging fossil fule use
- Quota obligations
- Tenders
- European Emissions Trading Scheme (Cap and Trade, CDM, JI)

With answers to these questions, it would then be possible to map out in more detail what the key milestones in a broader renewable technology roadmap would be for Europe.

	Technology Development (to 2010)	Technology Establishment (2010–2015)	Market Development (2015–2020)	Market Expansion (2020–2025)
Market Development	Individual country incentives/feed in tariffs, limits on installed capacity, public private partnerships	Broader based incentives, demand led purchase agreements, limits on capacity removed, long term purchase agreements	Harmonisation of cross border legislative, commercial and market conditions, insurance and guarantee arrangements	Creation of an open and competitive market for renewable and fossil fuel energy
Policy Requirements	UNFCC Copenhagen 2009, EU Directives on CO_2 storage and emissions	Increasing National and Local Policy, use of CDM, 2nd phase of ETS, potential for higher carbon prices in later years	REN Directive and GO introduced, 3rd phase of ETS, widespread CO_2 auctioning, other GHG control mechanisms e.g. Kyoto2	Implementation of a European strategic energy technology plan
Stakeholder Engagement	Niche interest, small but increasing number of technology providers and financing organisations Ongoing engagement with national and regional governments	Support from utilities and improved coordination with other renewables Alignment of business interests and broad financial support for new ventures	High levels of cooperation, establishment of joint governance arrangements for regional initiatives	

21. Juice From Concentrate, Reducing Emissions With Concentrating Solar Thermal Power. World Resources Institute (2009)

A roadmap for success

Key barriers

Key barriers to deliver CSP

Political

- A lack of political EU leadership and will
- Suitable legislative and commercial arrangements across the EU
- Lobbying by organisations with vested interests

Social

- EU concerns about locating energy generation in North Africa and Middle East
- Impact of development on local communities
- Interaction and linkages between countries in North Africa and the Middle East

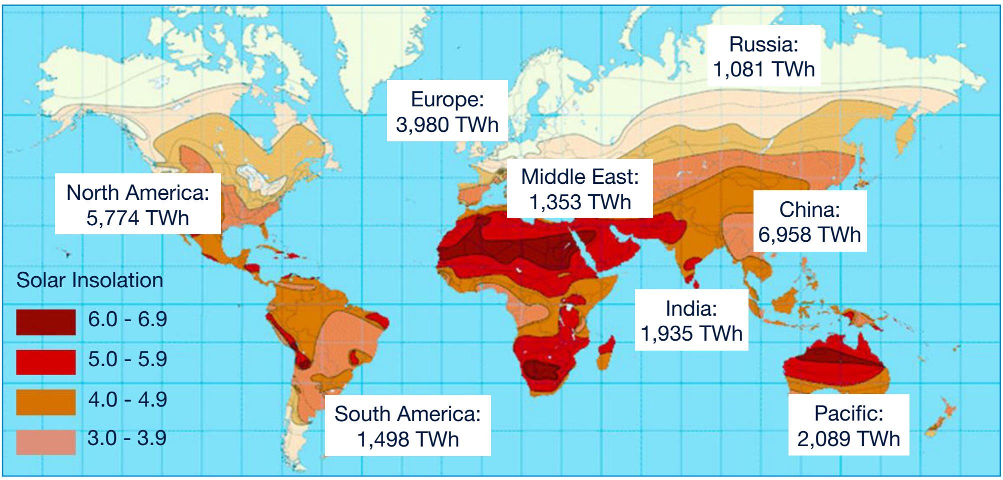
Economic

- Investment costs
- Certainty and incentives for investors
- Lack of a developed market structure for renewable energy (feed in tariffs, regulation, caps)
- Costs and timescales to build necessary infrastructure

Technology

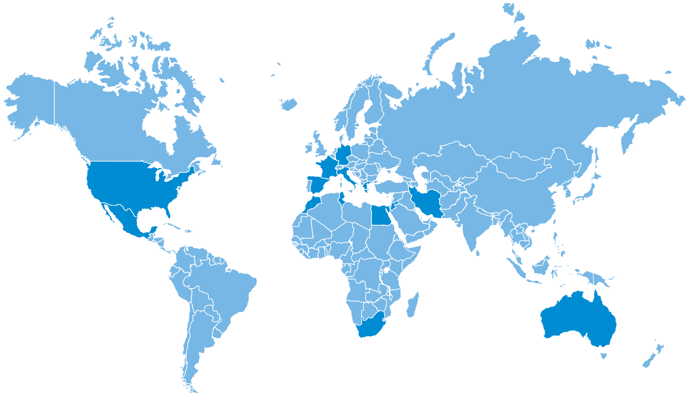
- Which CSP technology?
- Proof that the chosen technology can be scaled up to commercial levels
- Maintenance and operating requirements

Estimated global electricity consumption by geographical region by 2030[12]



Global distribution of CSP projects

A number of countries around the world most notably Spain, Australia and the US, already have a number of CSP plants in operation, with grid connections allowing local towns in those countries to derive most of their electricity requirements from clean sources. The map below illustrates some of the countries with existing and/or planned CSP installations in the coming years.



Algeria
Australia
China
Cyprus
Egypt
France
Greece
Germany
Iran
Israel
India
Italy
Jordan
Mexico
Morocco
South Africa
Spain
Tunisia
USA

Countries in bold are home to operational CSP sites. The remaining countries are at various stages of the CSP planning and development process.

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The challenge

We now know that substantial climate change is unavoidable and that it poses an immense risk both to mankind's everyday lives and the world around us. There is an urgent need to take action, but progress to date has been slow and limited in its impact.

The opportunity

With the impact of climate change and energy shortages on our doorstep, the world now needs to promote those solutions that can immediately cut global greenhouse gas emissions, and address other areas of risk.

The solution

As part of a multi-faceted approach to increasing the role of renewable technologies, Concentrating Solar Thermal Power (CSP) can play a key role. Enough solar energy reaches our planet every day to meet all of our energy needs. Research has concluded that it is possible to capture this energy – at its most intense points of impact, convert it into a storable and transmittable form, and transmit it efficiently to where it is needed.

This document outlines the opportunity CSP can play. It also highlights areas that require immediate intervention for it to achieve its potential.

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