



Solar Millennium AG

European Climate Foundation

3 December 2009

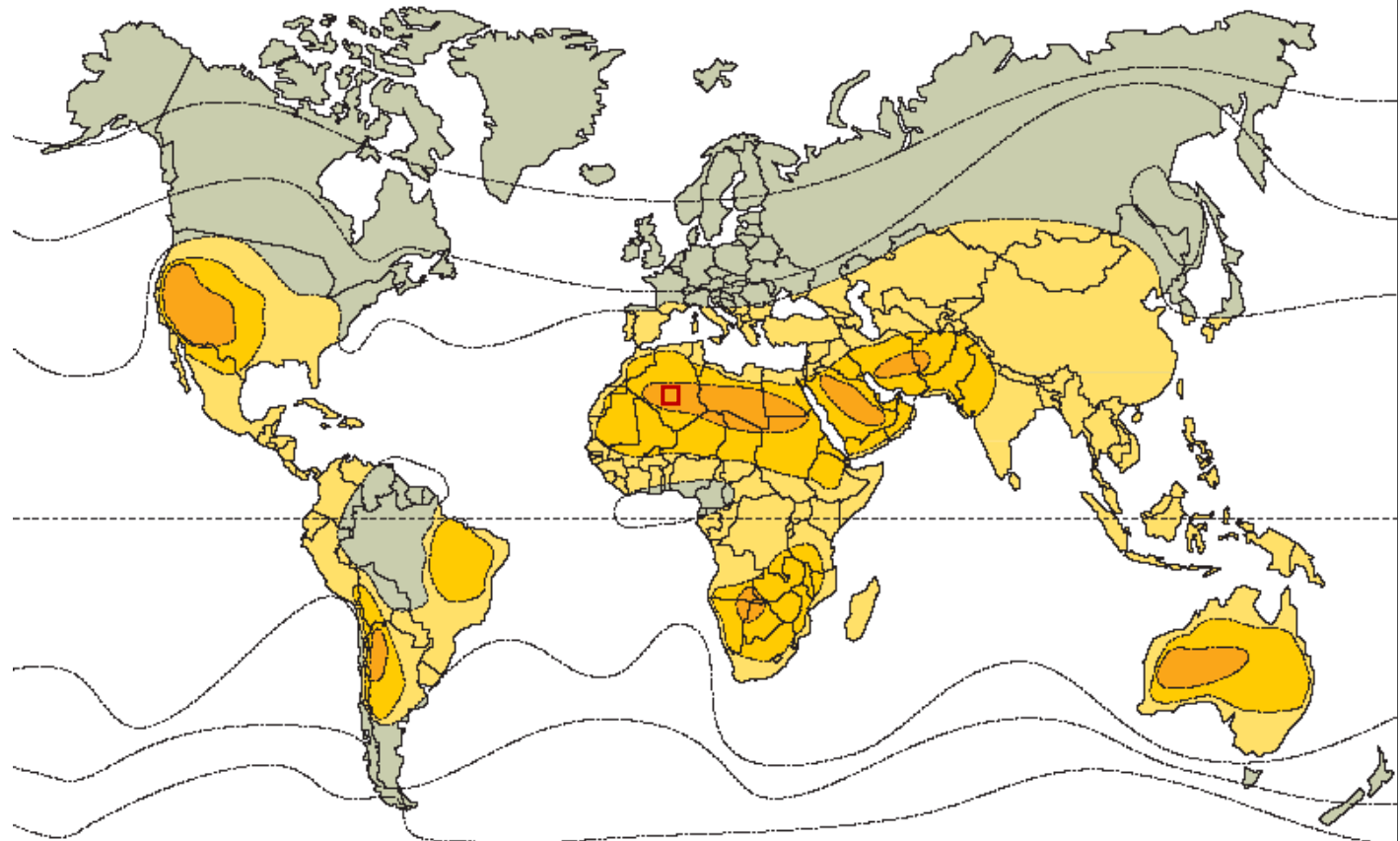
Solar Power is inexhaustible ...

Each year over 1 billion terawatt hours of solar radiation arrive at the Earth's surface. This corresponds to about 70,000 times of the world's current electricity demand. Thus, solar power has the biggest potential of all renewable energies.



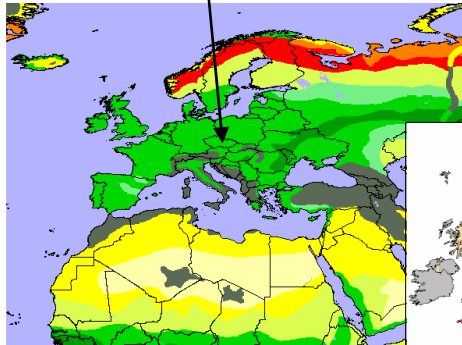
... usable at a vast number of possible sites ...

Only less than 3% of the total area of the Sahara desert covered with parabolic trough power plants would be sufficient to supply the world's electricity demand.

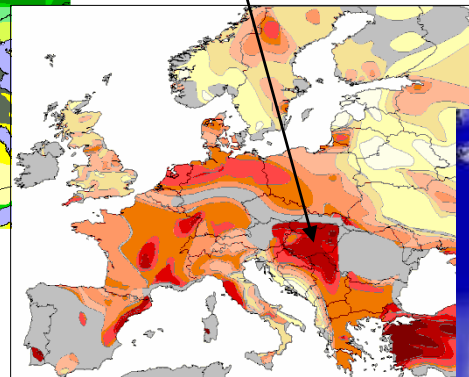


... and it offers the highest energy density amongst renewable energies

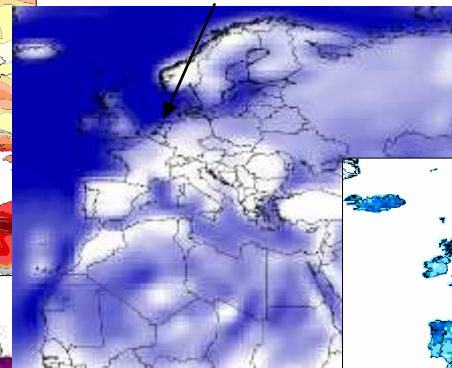
Biomass (1 GWh/km²a)



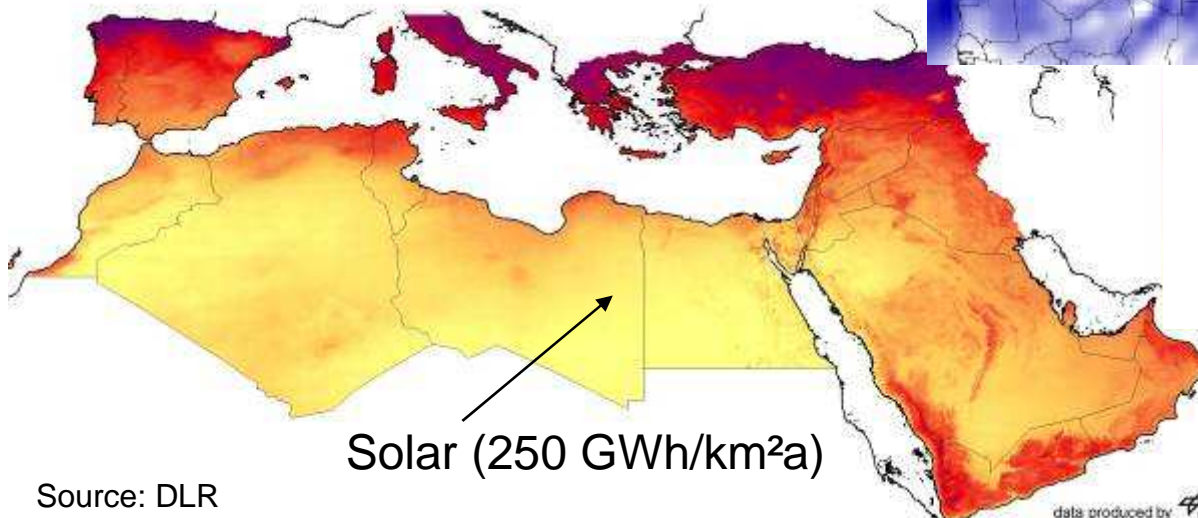
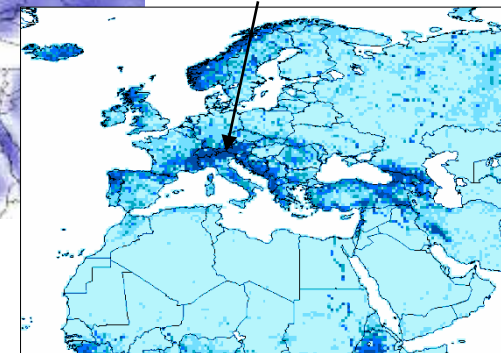
Geothermal (1 GWh/km²a)



Wind (30 GWh/km²a)



Hydro (30 GWh/km²a)



Solar (250 GWh/km²a)

In the MENA counties,
1 km² delivers about
1.5 million barrels of oil

Source: DLR

data produced by 

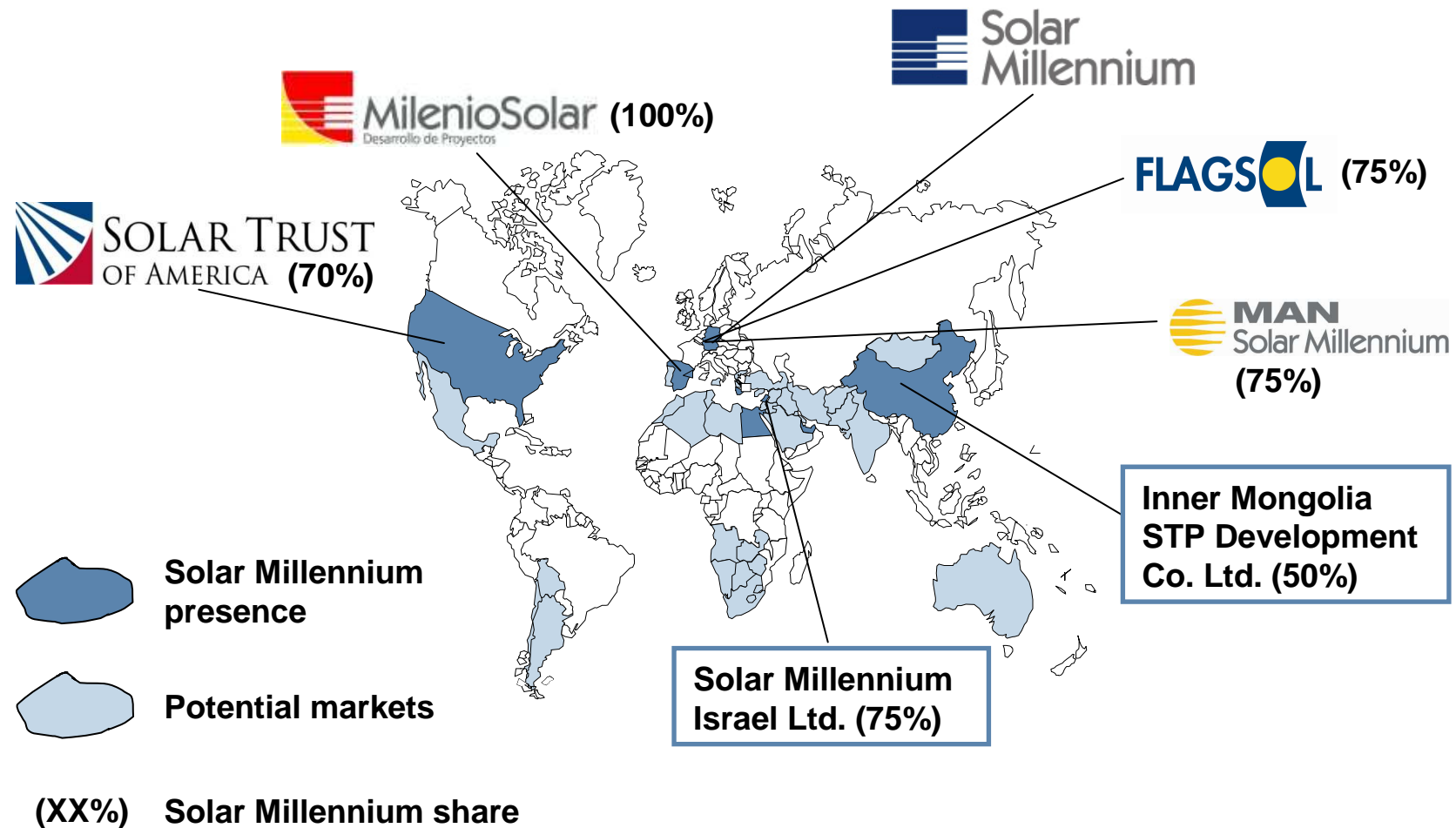
A specialist for solar-thermal power plants

Solar Millennium AG

- ... is a successful pioneer thanks to the early entry into the market (1998)
- ... develops the first parabolic trough power plants in Europe
- ... is a technological leader in parabolic trough power plants
- ... is supplying the technology for Egypt's first parabolic trough solar field
- ... is developing a multitude of new projects worldwide



Solar Millennium – local expertise for a global market



Proven technology: parabolic troughs

- The solar radiation is concentrated onto an absorber tube, situated at the focal line of the trough, and transferred into heat which is used to operate a steam turbine generating electricity.
- Commercially operated plants in California since 1984 have generated revenues of over US\$ 2 billion.
- They can be operated as pure solar power plants or in hybrid systems.
- Stable electricity production: Thermal storage means electricity production is independent of the momentary solar radiation.

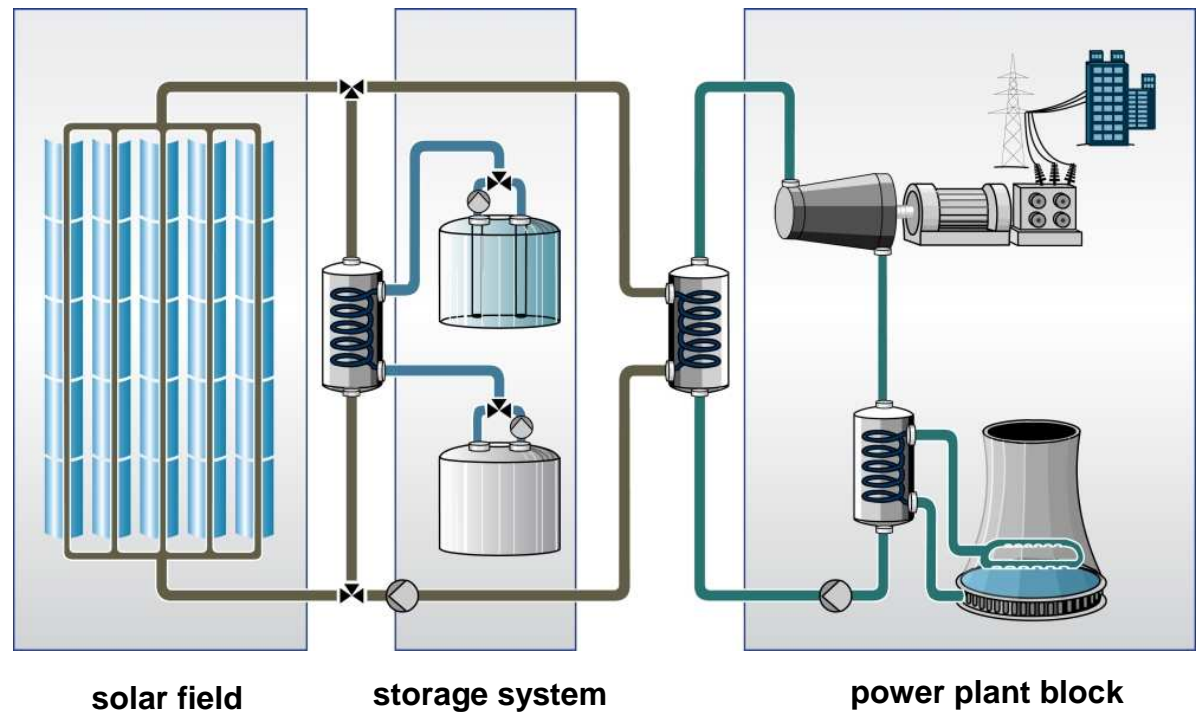


Technical description

Components of the parabolic trough power plant

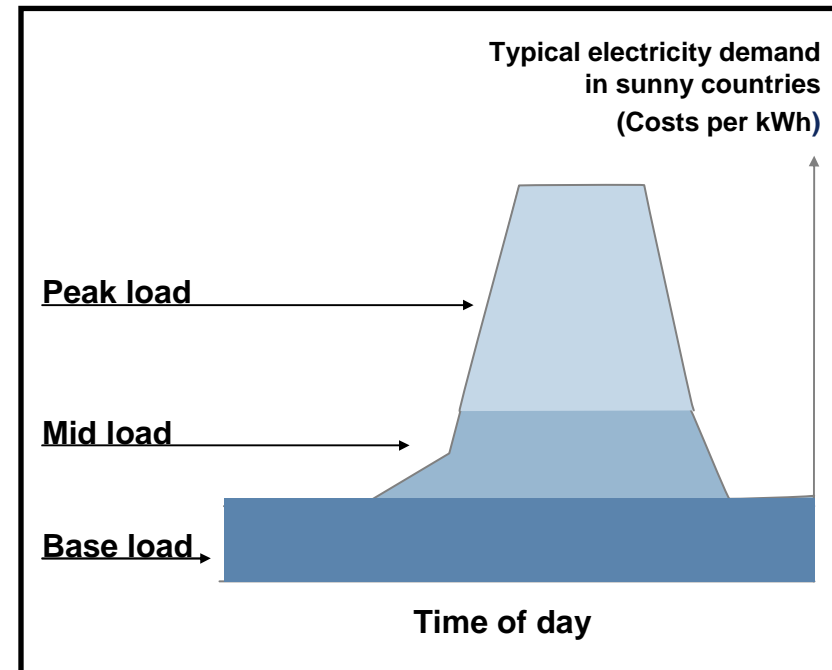
A parabolic trough power plant with thermal energy storage basically consists of three parts:

- solar field with heat transfer circuit
- storage system
- power plant block with turbine, generator and cooling circuit



Solar-thermal plants ideal for market requirements

- The electricity supplied from solar-thermal power plants fits ideally to the electricity demand in sunny countries (see graphic).
- Stable electricity production even when the sun does not shine thanks to thermal storage device.
- Solar thermal power plants provide grid stability in combination with other renewable energies.
- Technology is already competitive for peak-rate market prices.



First European parabolic trough power plant Andasol1 in operation



Andasol 1: Milestone for Solar Millennium

- World's largest solar power station with over 510,000 sqm of collector area (>70 soccer fields) and an annual net power generation of around 160 GWh/a
- Europe's first parabolic trough power plant as an important reference for new projects and an impulse for the international market development
- Officially inaugurated on July 1, 2009, on grid since December 2008
- Thermal storage allows to plan regular and stable electricity production, even during the night
- Andasol 1 supplies up to 200,000 people with solar electricity



Andasol 2: Operating in commissioning phase

Andasol 3: Construction of collector field



Great interest in CSP in North-Africa and Middle East: first project in Egypt

Construction of a natural gas/solar hybrid power plant (ISCC: Integrated Solar Combined Cycle) with a capacity of 150 MW

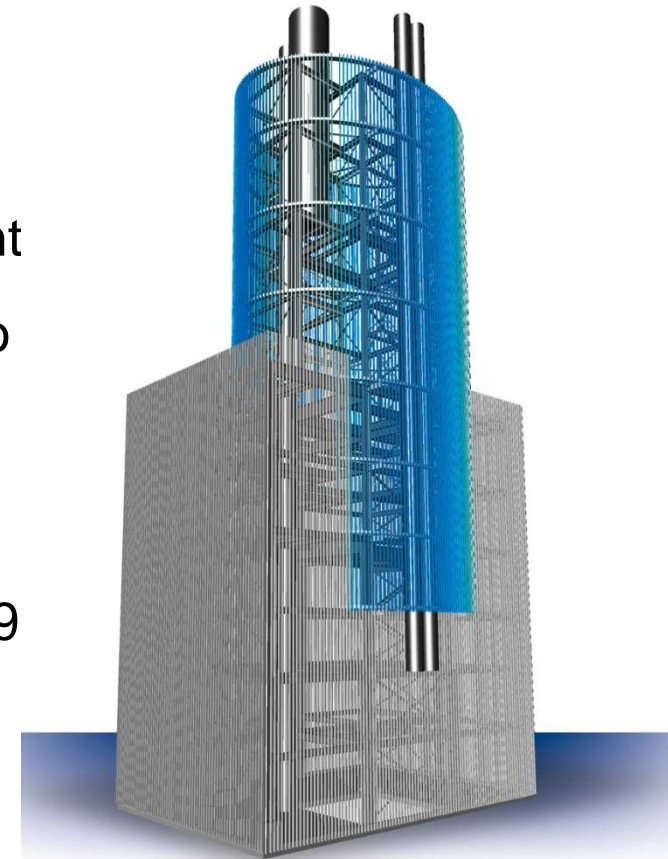
- Technology subsidiary Flagsol responsible for engineering, supervision and delivery of key components
- Start of construction at the beginning of 2008, commissioning planned for mid 2010
- Increasing interest for solar-thermal energy in the MENA region, also amongst OPEC countries



Entry into Blue Tower technology

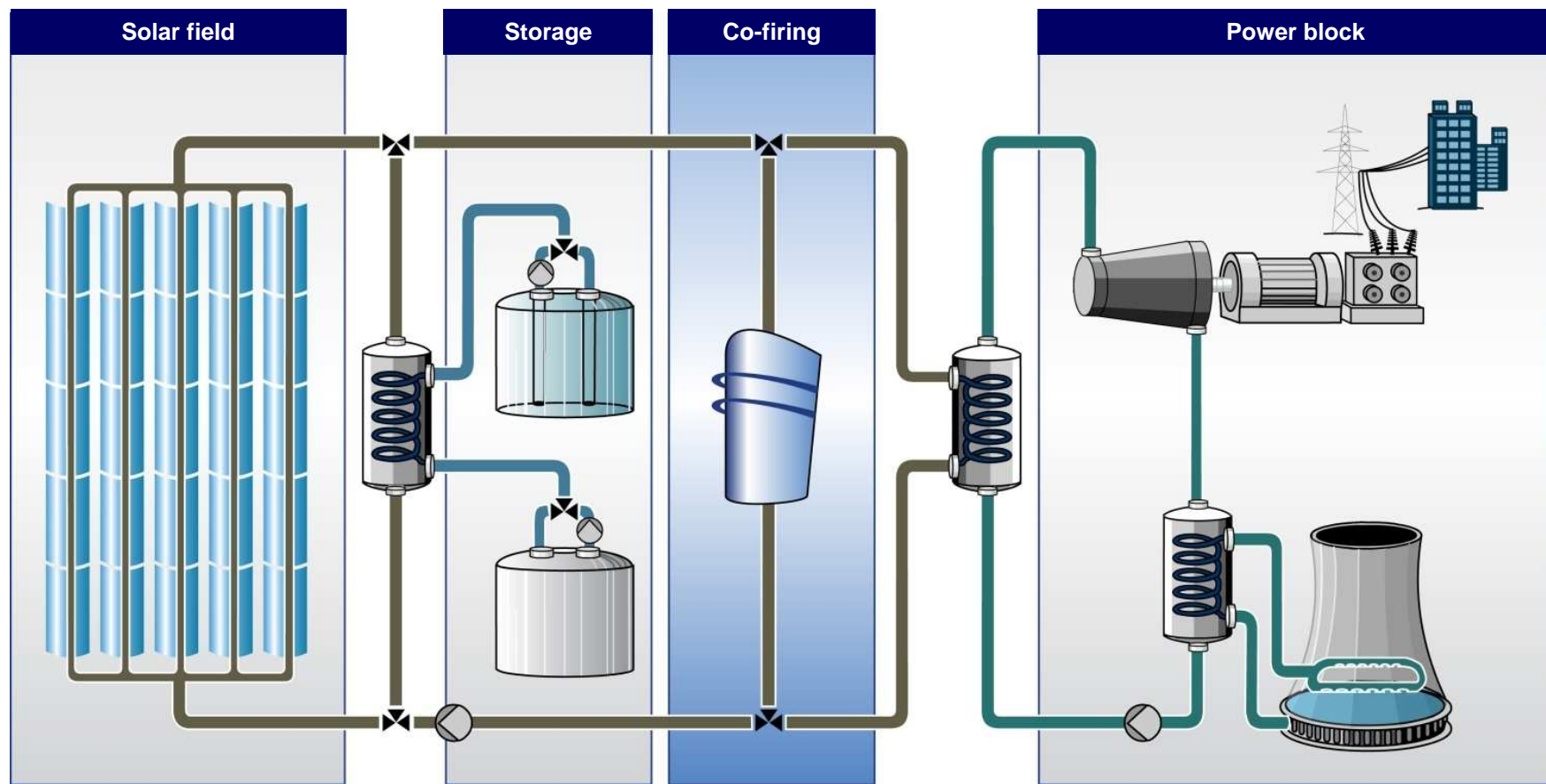
Technology for use of regenerative feedstock to generate electricity and hydrogen

- Technology is to enable round-the-clock hybrid operation of solar-thermal power plant
- Demonstration project in Herten/Germany to prove marketability with financial volume of € 24.6 million, subsidised by Land North Rhine-Westphalia with € 7.1 million
- Laying of foundation stone on March 5, 2009
- Start of commissioning at the end of 2009
- Capacity: ca. 13 MW_{th} / 5 MW_{el}
- Great potential worldwide



Conceptual integration of the Blue Tower into the parabolic trough technology

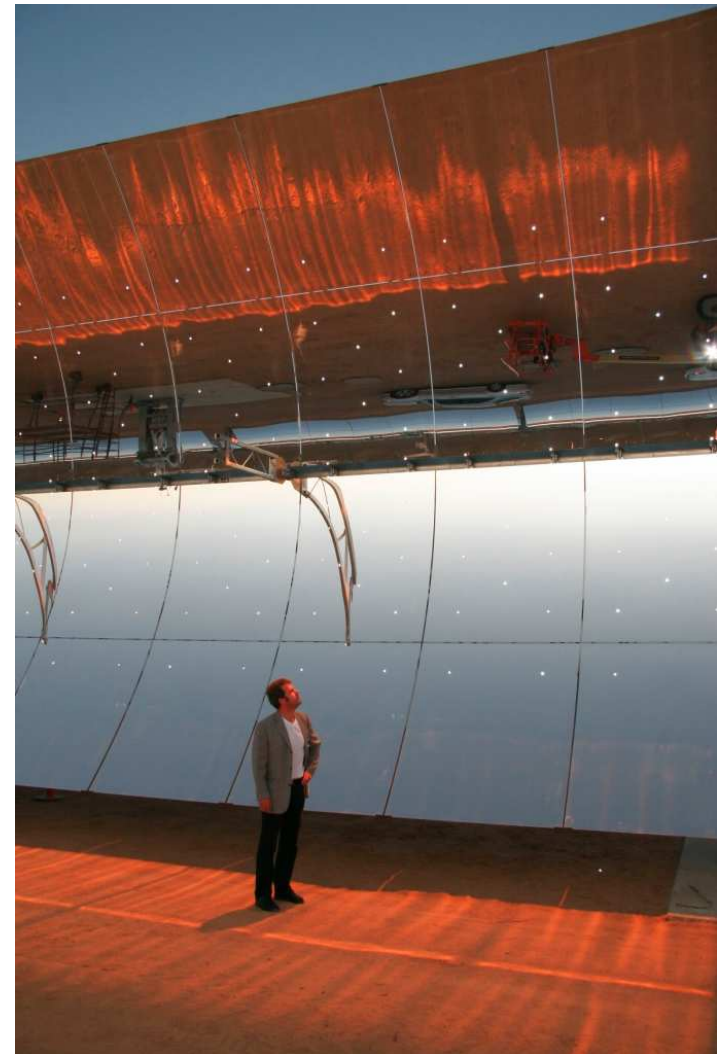
Blue Tower as co-firing system for round-the-clock operation of the solar power plant



Next collector generation as from 2010 on the market: HelioTrough lowers costs for solar fields significantly

Technology subsidiary Flagsol leading
in parabolic trough technology

- HelioTrough is the second collector generation developed by Flagsol
- Subsidised by the German Federal Ministry for Environment (Bundesumweltministerium)
- Improving competitiveness
- Lowering costs for collectors by 15-20%



Further R&D activities

Solar Millennium permanently develops further existing and new technologies to improve and expand its cutting-edge portfolio

- **Cost reduction:** Direct steam production and direct heating-up of molten salt, respectively, in absorber tubes to increase the temperature and efficiency; optimisation of collector design
- **Expansion of potential sites:** Dry cooling of solar thermal power plants to minimise water consumption
- **Expansion of possible usage:** Desalination of sea water; enhanced oil recovery by pressurised oil caves with steam produced in parabolic troughs

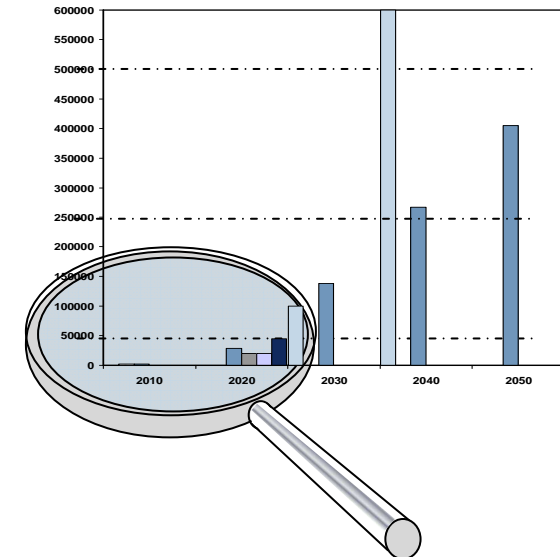
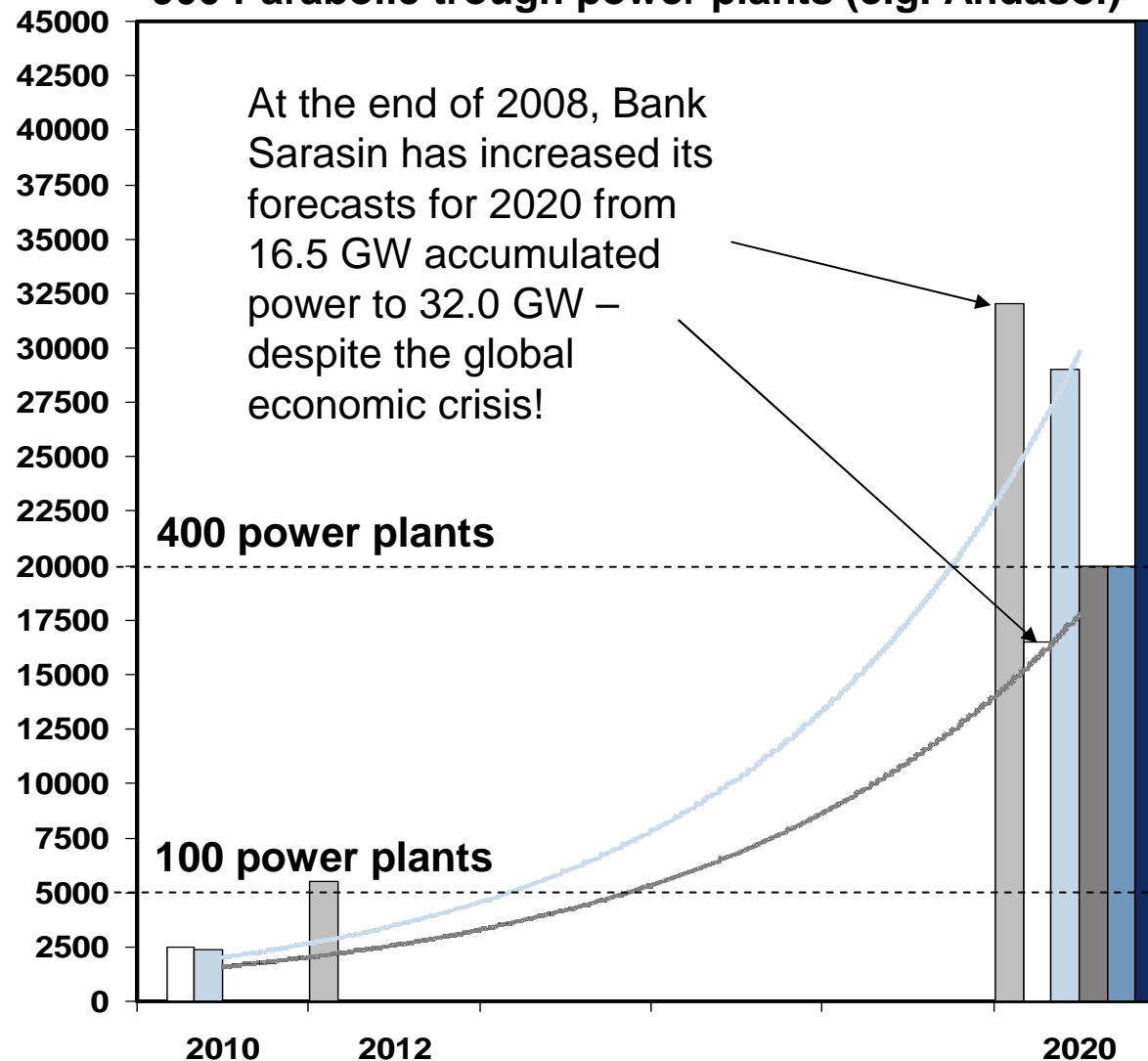


Huge potential for market growth

Power of solar-thermal plants /

MW

900 Parabolic trough power plants (e.g. Andasol)



Studies



Spanish Minister of Industry has announced pre-registration for Andasol 3 and Ibersol

- Feed-in tariff is guaranteed for the full power plant lifecycle provided that the projects are completed within the next 36/48 months
- Increased investment security facilitates rapid realisation of Andasol 3 and Ibersol in cooperation with investors
- Majority stake of Andasol 3 sold to Stadtwerke München, RWE and Rheinenergie; first stage of construction of the solar field (about 60,000 m²) already completed
- MAN Ferrostaal and Ibersol Kraftwerks GmbH invest in Ibersol project



USA: The next booming market – positive steps for a framework during the past months

Part of Barack Obama's 790 bn. US-\$ stimulus package dedicated to support renewable energies – incentives based on three pillars:

States:

Renewable Portfolio Standards (RPS) oblige utilities to generate electricity on a renewable basis

e.g. California:
20% by 2010
33% by 2020
planned

Federal:

Investment Tax Credits (ITC) of up to 30% of the total investment

respectively:

Direct grant of up to 30%

Federal:

Loan guarantee by the Federal Department of Energy (DoE)

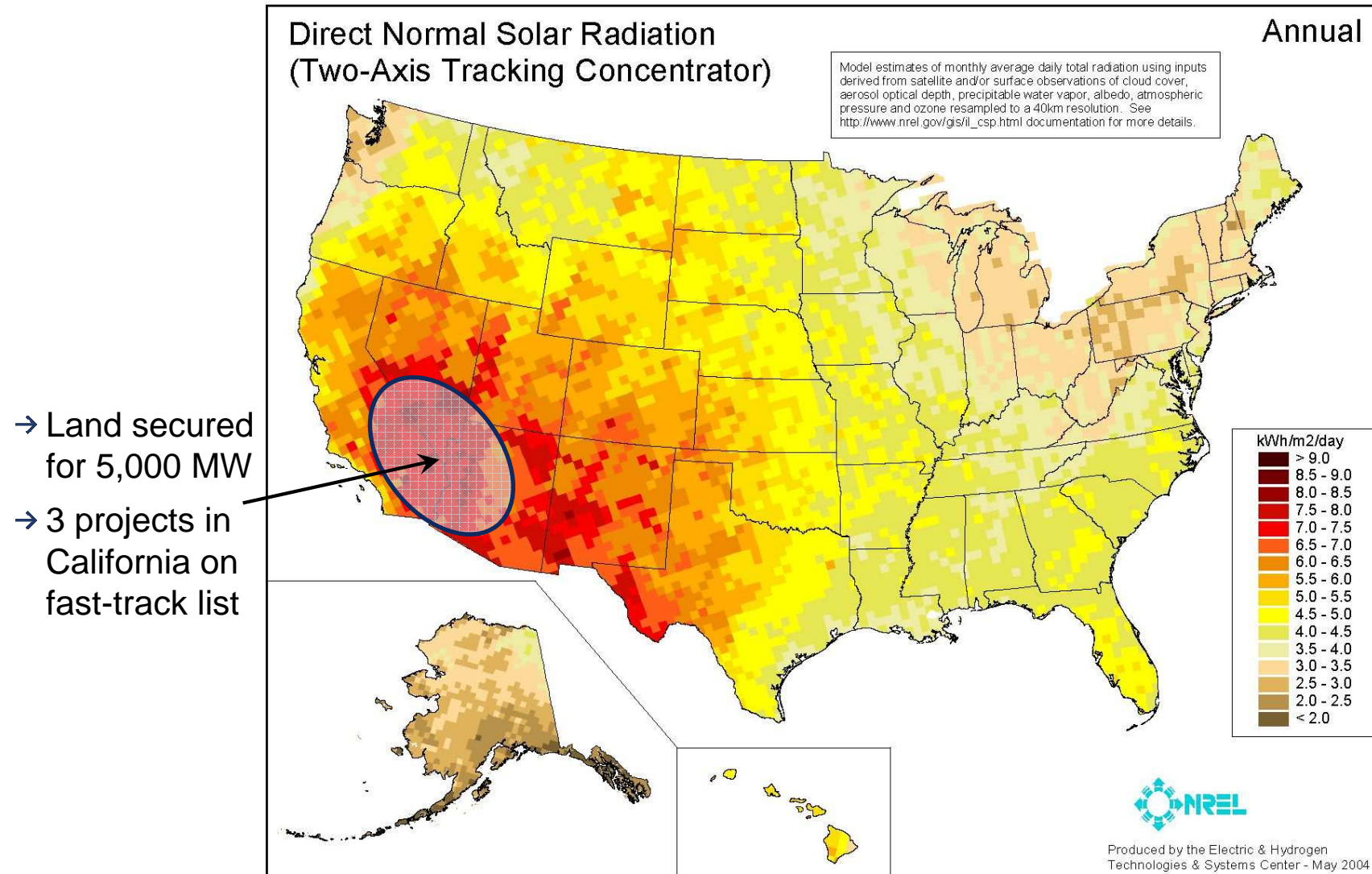
Solar Millennium excellently positioned in boom market USA

- Secured suitable land for projects with overall capacity of ca. 5,000 MW, short-listed for several projects of about 1,500 MW
- Memorandum of Understanding (MoU) signed with Nevada Energy in 03/2009 for at least one 250 MW power plant in the Amargosa desert
- Power Purchase Agreement (PPA) signed with Southern California Edison (SCE) in 06/2009 for two 242-MW power plants with an option for a third one, all of them on fast-track list; investment sum for each project about 1 bn. US-\$, beginning of construction at the end of 2010
- Solar Trust of America LLC (STA) as integrated industrial solar solution company for offering solar-thermal power plants in the USA



Kramer Junction - USA

Situation of Solar Millennium's solar thermal power plant projects in the USA



The current markets for Concentrated Solar Power (CSP) and their drivers

- **Spain** as first and main market with long-term guaranteed feed-in tariff
- **Italy/Greece/Portugal**: legal framework for feed-in tariffs and feed-in tariffs in preparation
- **Middle East** and **North Africa (MENA)** as emerging markets with calls for tenders and first plants under construction
- Development of the market in **China** where proportion of renewable energy capacity for energy supply has been stipulated by law
- Growing interest in solar-thermal power plants and announcements to expand renewable energy activities in many countries in **Asia, South America, Southern Africa, and Australia**

A Union for a renewable electricity super-grid

Foundation of the Union for the Mediterranean in summer 2008:

Solar energy as a key issue of the cooperation between the EU and the MENA countries: implementation of a Mediterranean Solar Plan.

In 2050 Concentrating Solar Power Plants in the Mediterranean Region will deliver twice as much electricity per year as wind, PV, biomass and geothermal plants together.

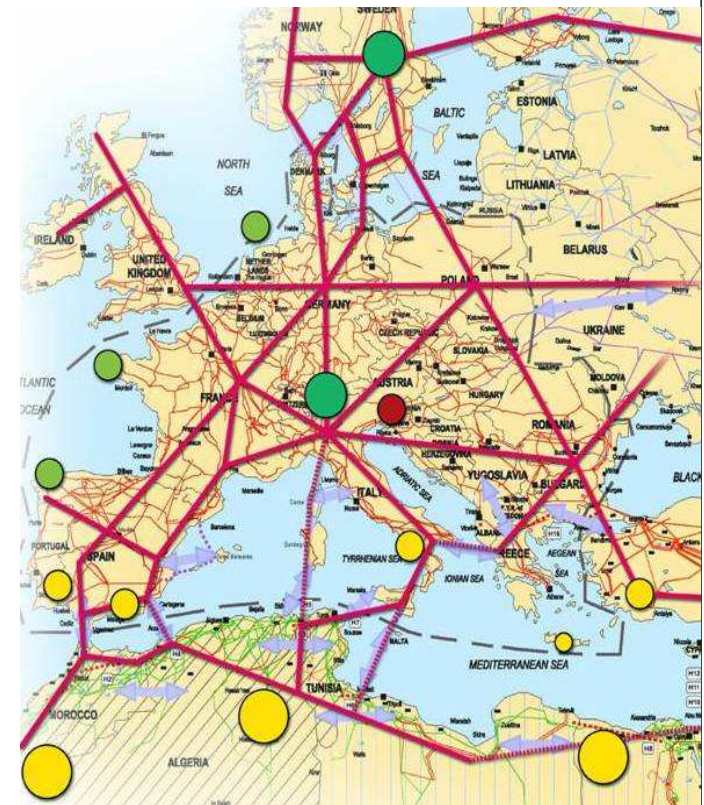
(Med-CSP-Study by German Aerospace Center, DLR)

In 2050, about 15 % of the European electricity demand can be met by solar imports from the Middle East and North Africa.

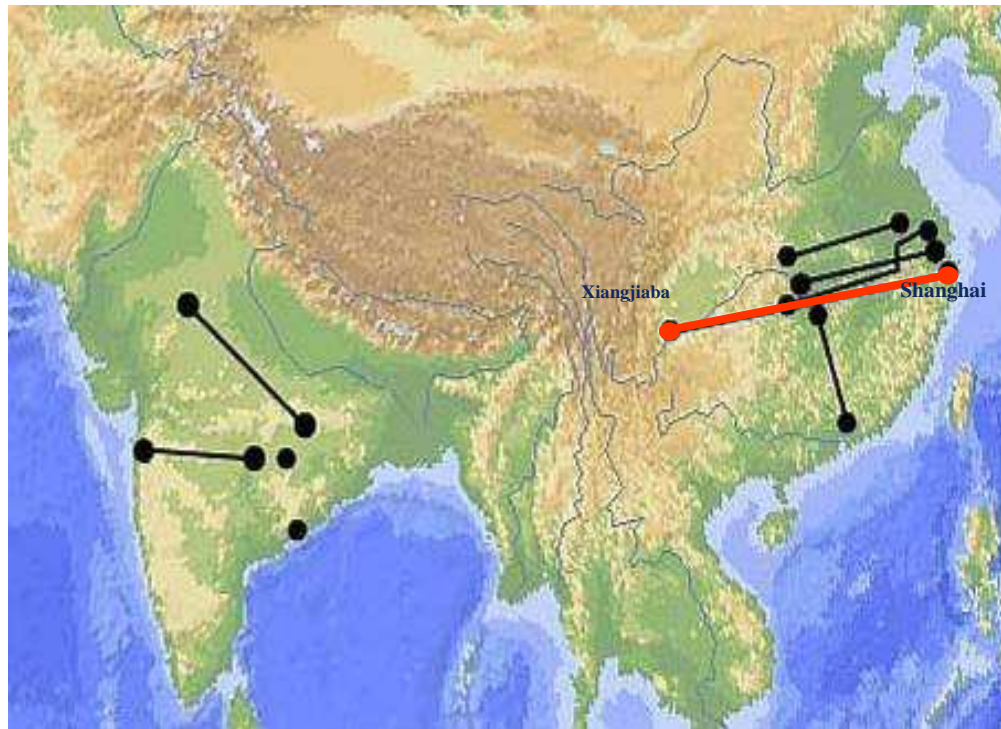
(Trans-CSP-Study by German Aerospace Center, DLR)

“We must use the chances provided by intelligent solar-politics across the globe, in order to promote economic development in a sustainable manner. This also prevents conflicts over raw materials or water getting out of control in the medium term...”

(German Federal Foreign Minister Steinmeier)



World's largest HVDC line under construction in China: Remote hydropower Xiangjiaba - Shanghai



Main data

Commissioning year

Pole 1: 2010

Bipole: 2011

Power rating: 6 400 MW

No. of poles: 2

DC voltage: ± 800 kV

Length of over-head DC line: 2 071 km

Losses: < 7%

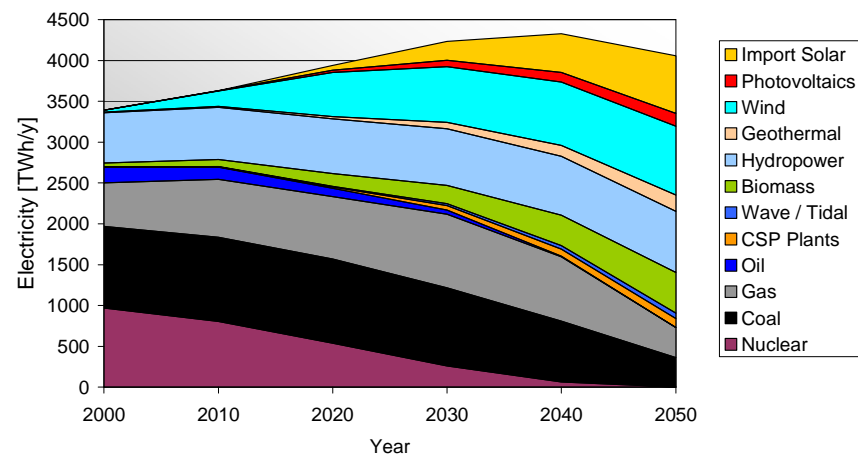
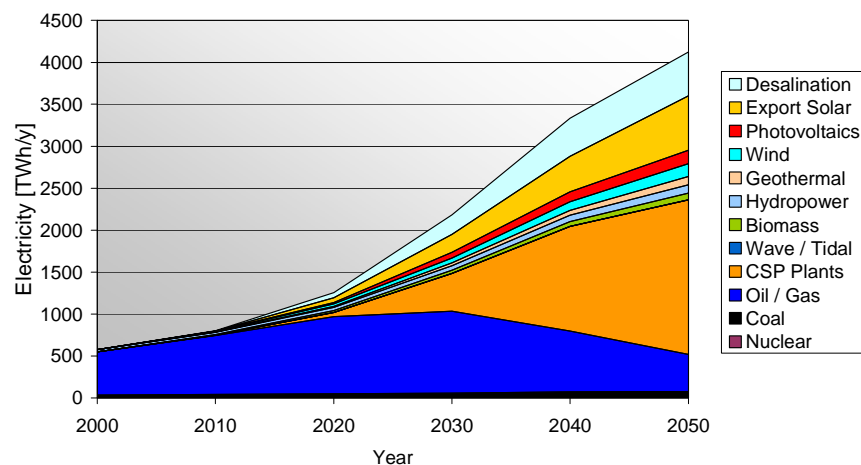
Main reason for choosing HVDC: Long distance

Source: **ABB**

The Desertec initiative supports an independent Pan-European renewable electricity supply

The Desertec concept, developed by the TREC (Trans-Mediterranean Renewable Energy Cooperation) initiative of the Club of Rome, describes the perspectives of a sustainable power supply using a Pan-European super-grid which inter-connects Europe and the MENA countries by High Voltage Direct Current (HVDC) transmission lines. The following figures were published based on DLR scenarios (Trans-CSP):

- € 400 bn. to build up solar-thermal power plants (ca. € 350 bn.) and HVDC transmission lines (ca. € 50 bn.) by 2050
- Import of about 15% of electricity to Europe produced by solar-thermal power plants in the MENA-region by 2050



DII GmbH founded in Munich on 30 October 2009

Objective:

→ Analyse and develop the technical, economic, political, social and ecological framework for carbon-free power generation in the deserts of North Africa

Among the DII's main goals are:

→ Drafting of concrete business plans and associated financing concepts

→ Initiating of industrial preparations for building a large number of networked solar thermal power plants distributed throughout the MENA region

→ Produce sufficient power to meet around 15% of Europe's electricity requirements

→ Providing a substantial portion of the power needs of the producer countries

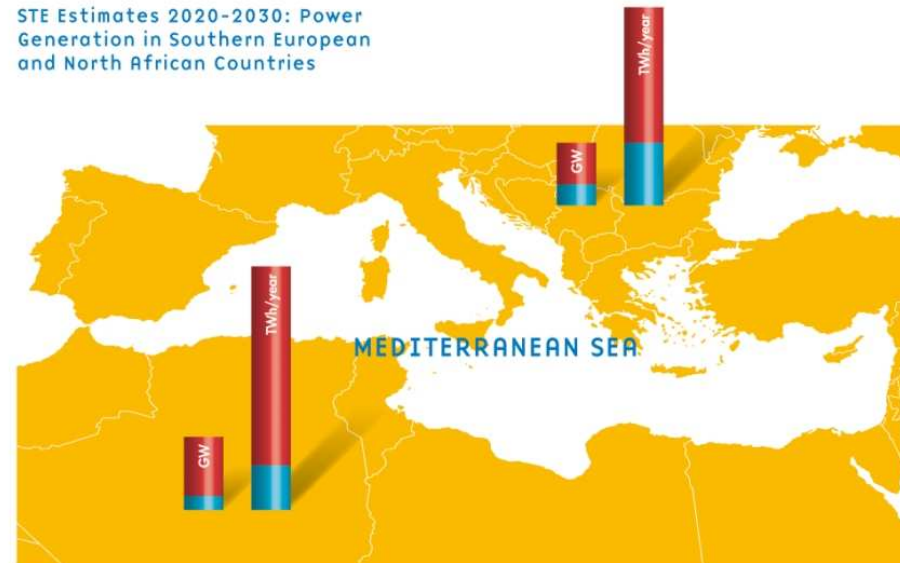
All of the DII's activities will be aimed at developing viable investment plans within three years of its establishment including shareholders from different countries.



STE: Developing a Regional Long-Term Strategy

A Full Renewable Energy System and Sustainability

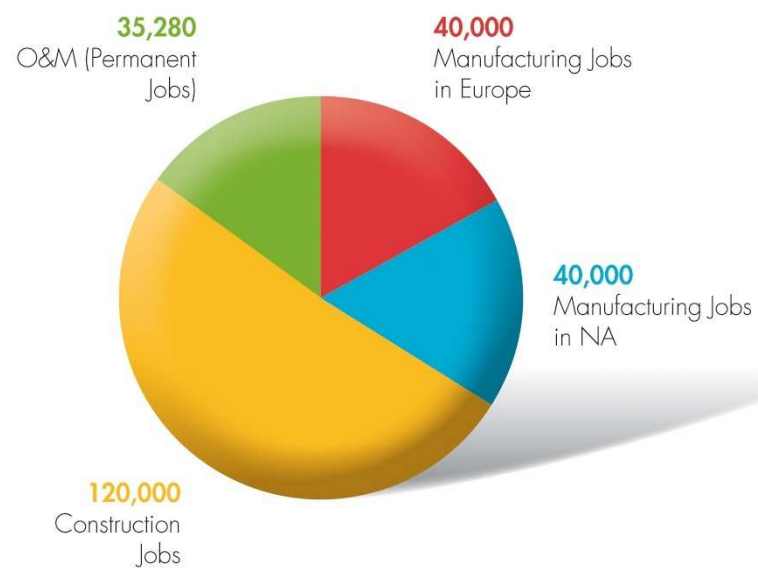
STE Estimates 2020-2030: Power
Generation in Southern European
and North African Countries



| | | 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 |

Solar Power: MSP Costs and Benefits

Employment Projections by 2020 (man/year)



ESTELA

European Solar Thermal Electricity Association

- ☐ Supports the emerging European solar thermal electricity industry
- ☐ Promotes the generation of solar power in Europe and abroad, mainly in the Mediterranean area
- ☐ Collaborates with the EU institutions, MS authorities and UfM countries Administrations where no national association is in place





ESTELA

European Solar Thermal Electricity Association

Renewable Energy House

Rue d'Arlon 63-67

B – 1040 Brussels

Tel. : + 32 (02) 400 10 90

estela@estelasolar.eu



Welcome to the Solar Millennium!



Contact

Dr. Stefan Eckhoff
(Head of Investor Relations)

Solar Millennium AG
Nägelsbachstr. 40
D-91052 Erlangen
Germany

Tel.: +49-9131 9409-0
Fax: +49-9131 9409-111
Email: investor@SolarMillennium.de
Web: www.SolarMillennium.de

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