European Solar Thermal Electricity Association

"Progress and opportunities with CSP (Concentrated Solar Power) for Europe‘’

Henk de Vries

Chairman [**EUKEP**]*)

19.11.2008

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*) **EU**ropean Knowledge **E**conomy **P**latform

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Solar Power Technologies

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Presentation content:

- CSP Basics
- Driving organizations
- Role of EU / Europe
- Challenges, Opportunities
- Co-operation

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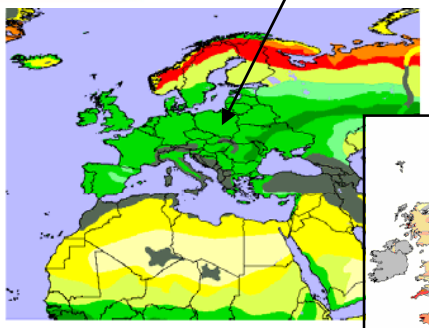
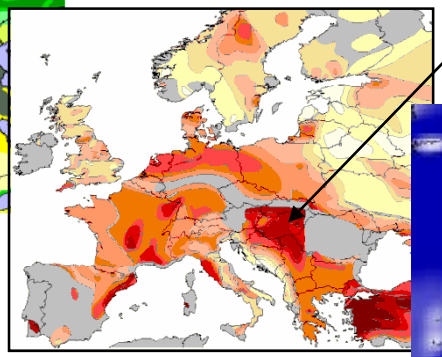
Renewable Energy Resources in EUMENA

in brackets: (Typical Yield in $GWh_{el}/km^2/y$)

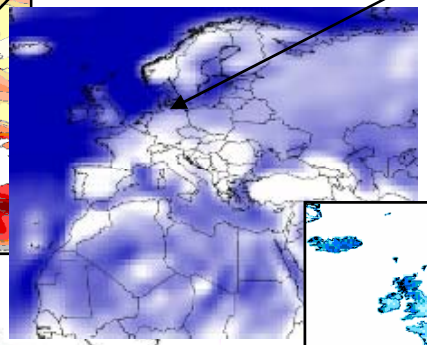
Biomass (1)



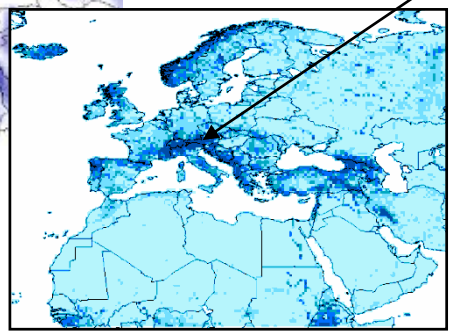
Geothermal Energy (1)

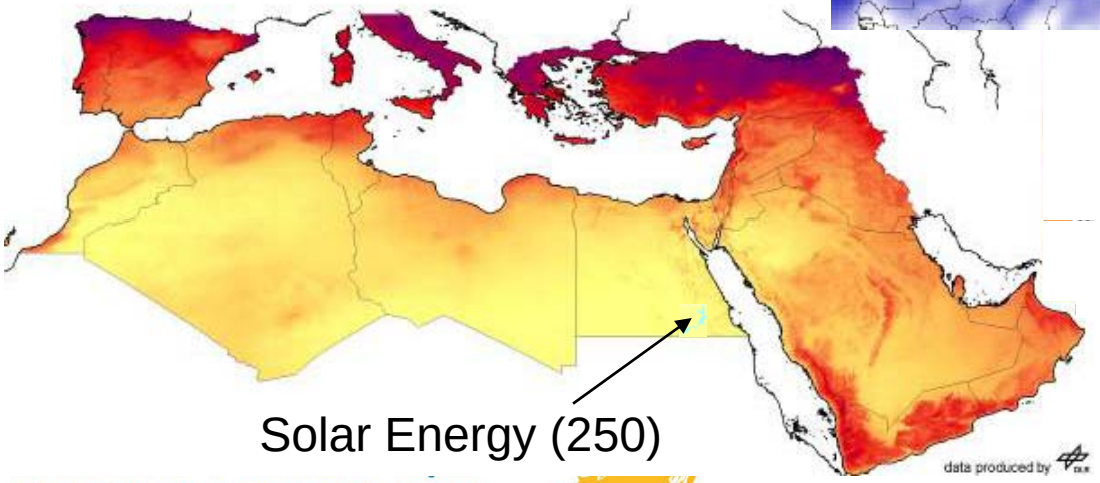


Wind Energy (30)



Hydropower (30)





Solar Energy (250)

A CSP plant of the size of Lake Nasser can deliver energy equivalent to Middle East oil production

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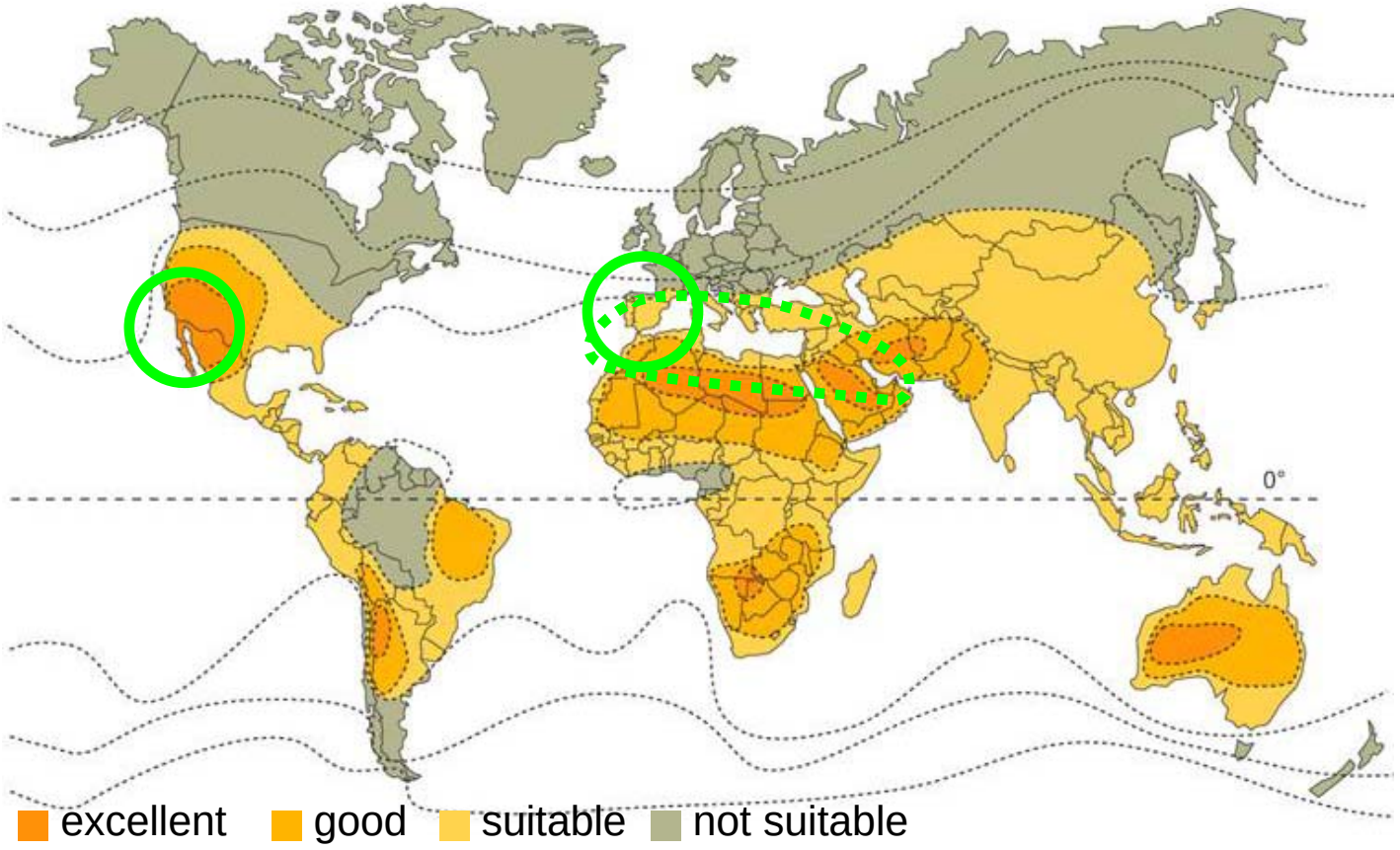
Max. Solar area's/ markets



Source: Solar Millennium AG, Erlangen

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Industry Members of ESTELA

ACS

Solar Millennium

ABENGOA

IBERDROLA

cobra

SENER

SCHOTT glass made of ideas

endesa

acciona Solar

CONERGY

Kraftanlagen München GAH Gruppe

Enel L'ENERGIA CHE TI ASCOLTA.

MAN Solar Millennium

ALSTOM

EVONIK INDUSTRIES

PRO TERMOSOLAR

senior Flexonics berghöfer

Institutes:

DLR

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What's ESTELA ? *)

- An European Association built on the basis of the former European Solar Thermal Power Industry Association, « ESTIA »
- Created to support the emerging European industry for the construction of thermal electricity power plants in Europe and abroad, mainly in the Mediterranean region (MENA)
- Involves all main actors in Europe
- Is based in Brussels

*) Sources: DLR, Schott

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Set-up of ESTELA

- Constitution: 1st June 2007
- Promoters: Protermosolar, Cobra (E) SCHOTT (D)
- 1st General Assembly: September 18, 2007
- Fully operational: January 2008
- Full members by January 2008: > 20, Meanwhile > 30.
- Location: Brussels in the Renewable Enegy House

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Objectives (1)

- To promote high and mid temperature solar technologies for the production of thermal electricity to move towards sustainable energy systems and combat climate change
- To promote thermal electricity in Europe at policy and administrative levels (local, regional, national al EU)
- To support Union's action in favor of European industry development and to contribute to reach the Union's energy objectives, main Renewable Energy targets
- To support research and innovation, including vocational training, and favoring equal opportunities

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Objectives (2)

- To promote excellence in the planning, design, construction and operating of thermal electricity plants
- To promote thermal electricity at international level, mainly in the Mediterranean area and developing countries
- To co-operate at international level to contribute sustainable development and combat climate change
- To represent the solar thermal electricity sector at European and world levels
- To organise meetings, workshops, conferences and other events to promote solar thermal electricity

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Who is [EUKEP]

- Independent organisation to drive the EUropean Knowledge Economy
- Do-oriented: from what to how?
- Focus-areas 2006-2009 Program:
  - Renewable Energy
  - Creative Industry
  - Healthcare
  - Social Innovation
- Funded by Projects
- Organisation: core team with associated consultants

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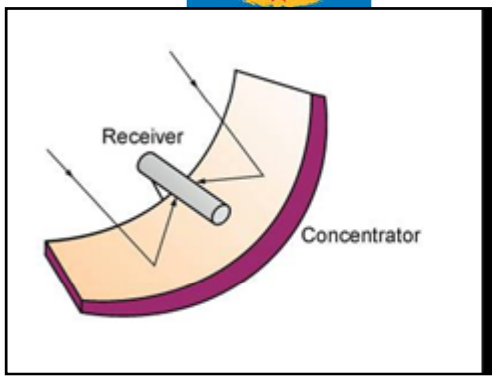

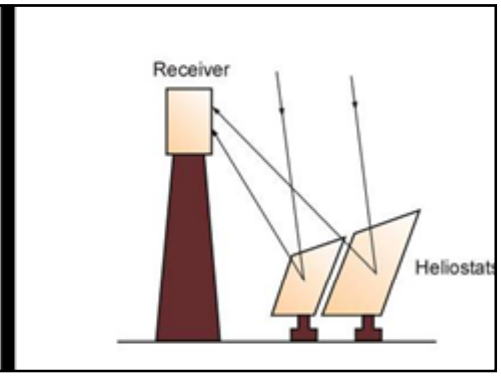

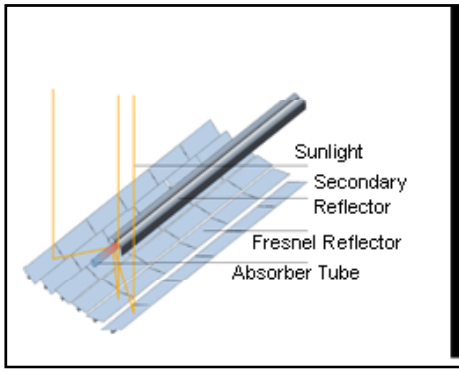

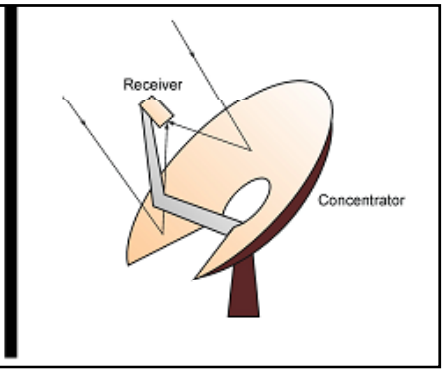

	Capacity MW_{el}	Concen-tration	Peak Solar Efficiency	Annual Solar Efficiency	Thermal Cycle Efficiency	Capacity Factor (solar)	Land Use m^2 (MW h $y^{)-1}$
Trough	10 - 200	70 - 80	21% (d)	10-15% (d)	30-40% ST	24% (d)	6-8
				17-18% (p)		25-70% (p)	
Fresnel	10 - 200	25 - 100	20% (p)	9-11% (p)	30-40% ST	25-70% (p)	4-6
Power Tower	10 - 150	300 – 1000	20% (d)	8-10% (d)	30-40% ST	25-70% (p)	8-12
			35% (p)	15-25% (p)	45-55% CC		
Dish-Stirling	0.01 - 0.4	1000 - 3000	29% (d)	16-18% (d)	30-40% Stirling	25% (p)	8-12
				18-23% (p)	20-30% GT		

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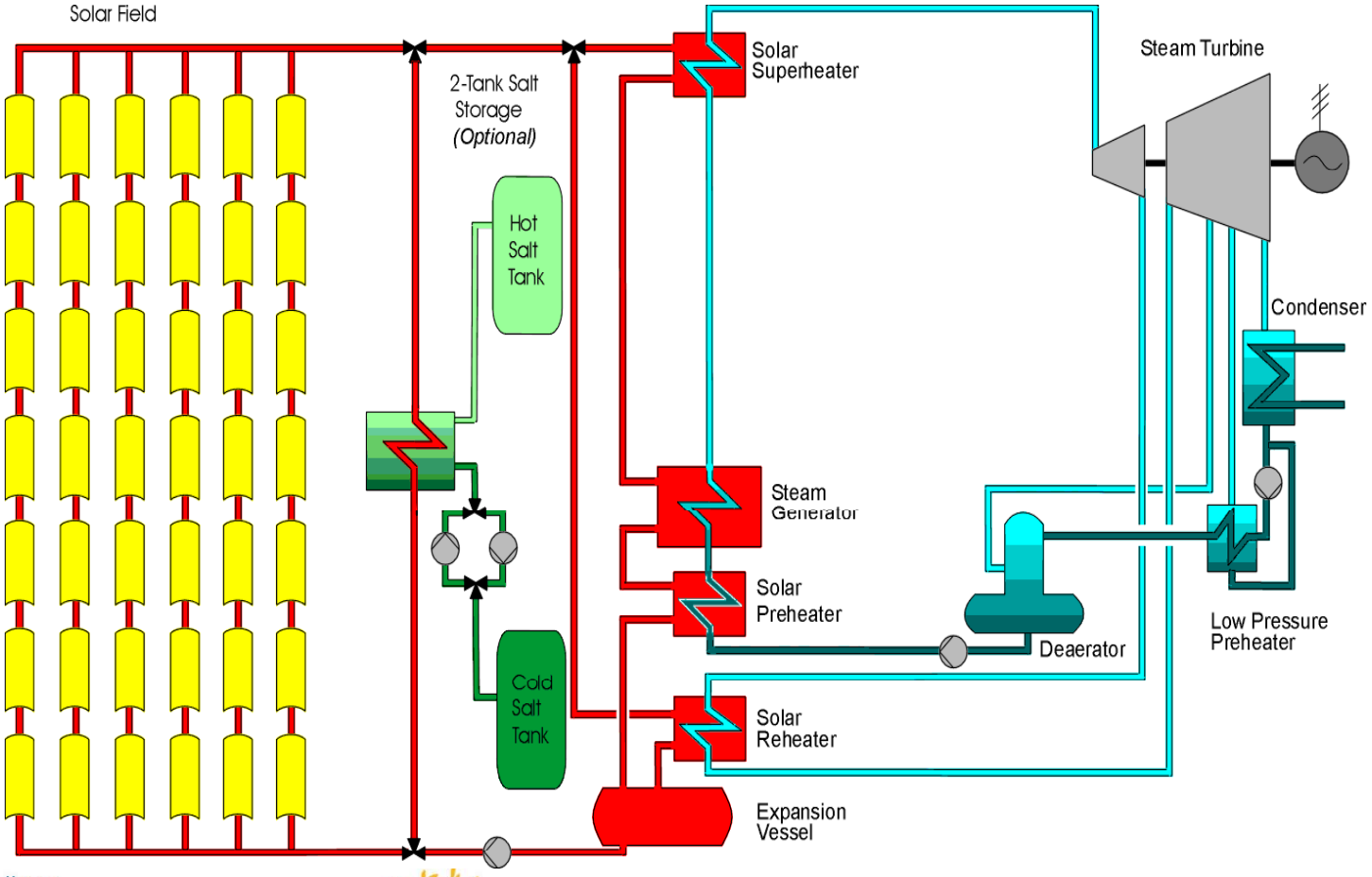
CSP PLANTS: PROCESS DIAGRAM



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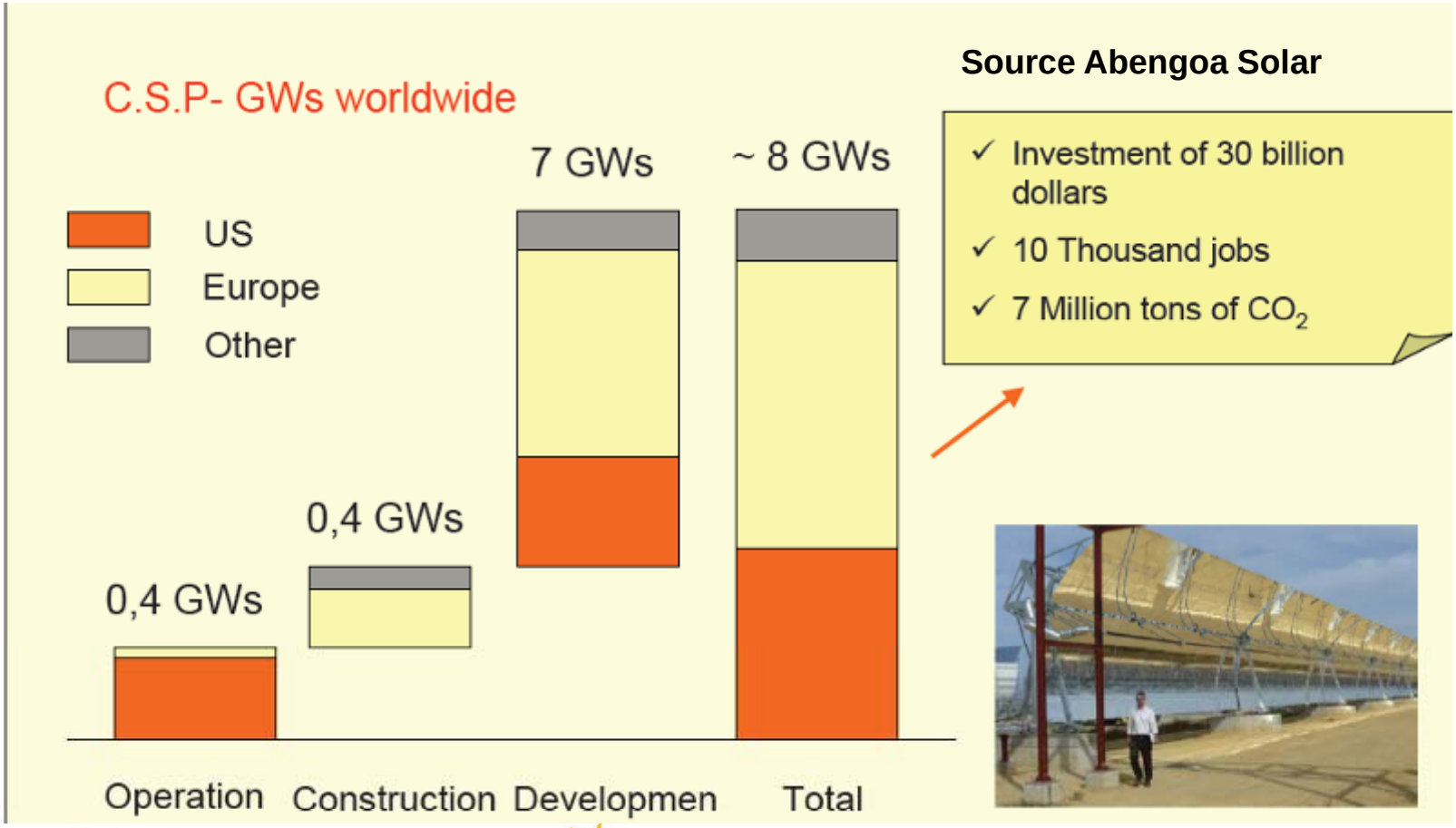
Installed base:



Source Abengoa Solar

- ✓ Investment of 30 billion dollars
- ✓ 10 Thousand jobs
- ✓ 7 Million tons of CO_2

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The Role of the EU

Push technology, pull demand, push generation

Market development and penetration:

- ❑ **Install demand pull instruments, promote feed-in-laws as most powerful instrument to push generation**
- ❑ **Open the European transmission grid for solar power from North Africa and secure this power import by implementing demand pull instruments**

Technology:

- ❑ **R&D-funding for material, component and system development (e.g. coatings, storage, direct steam/molten salt systems, adapted steam generators, beam down)**
- ❑ **Fund demonstration plants to push new technologies ➔**

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PS10 (2007) & PS20 (2008)

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Other EU CSP projects:

- Major overall CSP studies/analyses of Market/ Potential
- Molten Salt experiments with Towers.
- DISS (Direct Solar Steam) & DISTOR
- SOLAIR: Receiver components
- EURODISH: Reducing costs
- SOLGATE: Solar Hybrid GasTurbine
- HYPHIRE: Hybrid Sterling with Bio-gas
- EUROTHROUGH: Low cost Desalination
- SOLAR CHEMISTRY: Zn-Ox, Hydrogen, Methane split.

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CSP Technology

provides sustainable, clean and reliable Power from 10 kW to 200 MW

Parabolic Trough:
- Size: 50 - 200 MW
- proven utility scale technology
- commercial operation since 1984
- Solar One, Boulder 2008
- preferred technology for new plants in USA/Spain/MENA

Solar Tower:
- Size: 50 - 100 MW
- Demonstration plants built in 80‘s (not in Grid yet)
- new 10-15 MW plants in Spain

Linear Fresnel:
- Size 50 - 200 MW
- in study/exp. phase

Hybridization projects with e.g. Bio-mass

Dish Stirling:
- Size 25 kW (modular)
- few installations operating
- applications partly competing with PV, however . . .
- CSP mix possible with PV (Ga-As converter).

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Drivers for CSP in the South West of the US

SEIA expectation:

- next 5 years: CSP market will reach 1.5 GW annually
- next 10 years: 3 GW annually
- issues to be solved: ITC, transmission, state incentives, permits, land,....

Update

Utility / State	Capacity	Comment
Arizona Public Service, AZ	1 MW	Operational
Florida Power & Light SEGS, CA	24 MW	Under construction (repowering upgrade)
Nevada Power & Light, NV	64 MW	Operational
Southern California Edison, CA	500 MW	Under PPA contract
Southern California Edison, CA	350 MW	Contractual expansion option
San Diego Gas & Electric, CA	300 MW	Under PPA contract
San Diego Gas & Electric, CA	600 MW	Contractual expansion option
San Diego Gas & Electric, CA	100 MW	Under PPA contract
Pacific Gas & Electric, CA	553 MW	Under PPA contract
Pacific Gas & Electric, CA	500 MW	Under MOU Agreement
Total 2007 U.S. CSP contracts	**2,589 MW**	

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Nevada Solar One Power Plant

- Size: 64 MW solar only
- Annual capacity: 130 GWh
- Mirror area: 357,200 m²
- Project developed by SolarGenix Energy since March 2003
- on grid since June 2007
- 20 years PPA with Nevada Power Company and Sierra Pacific Power Company

acciona Solar

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Boulder City, NV
(Courtesy of Acciona Solar Power Inc)

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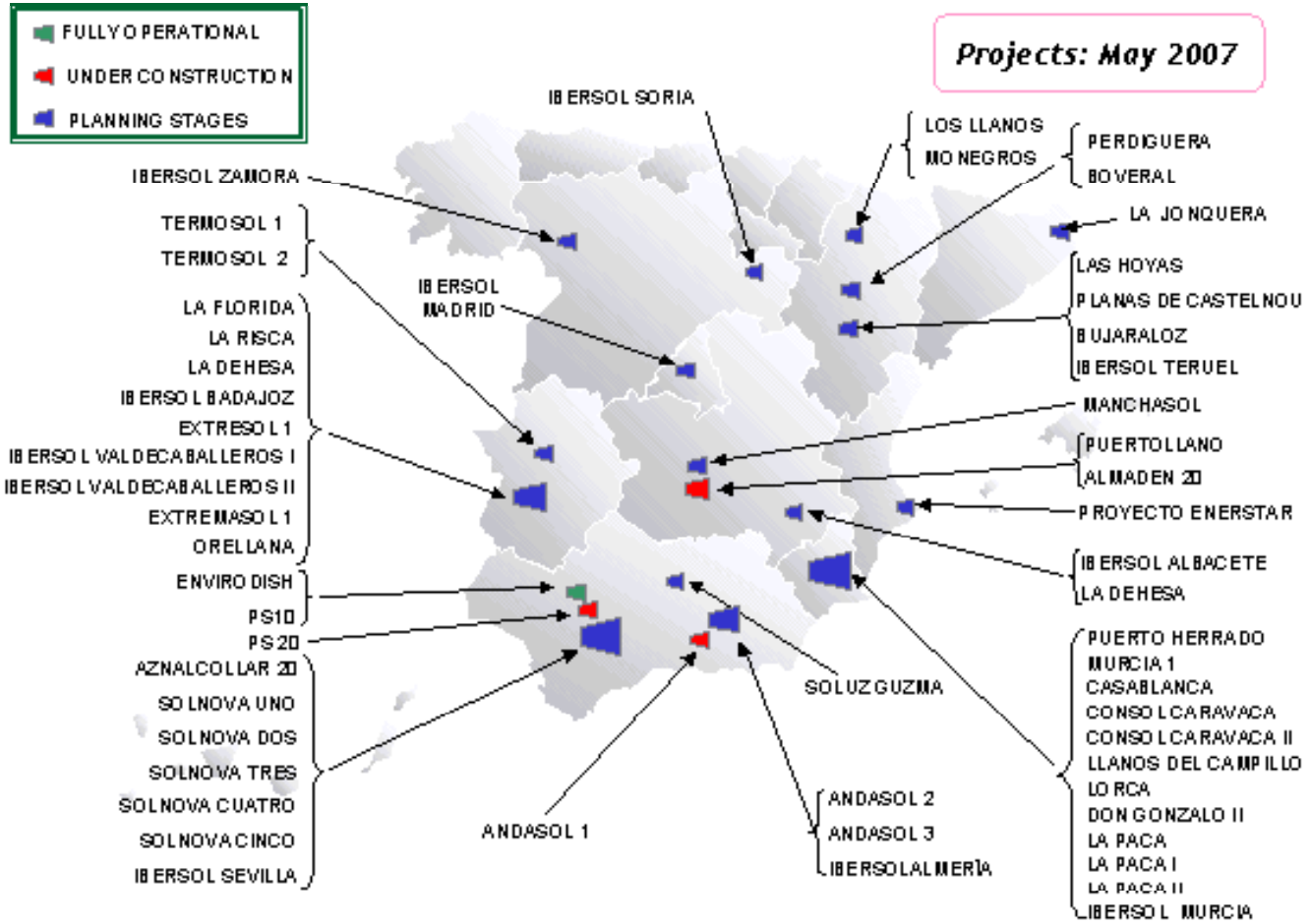
Spain: feed-in law is driver

about 60 projects currently under development



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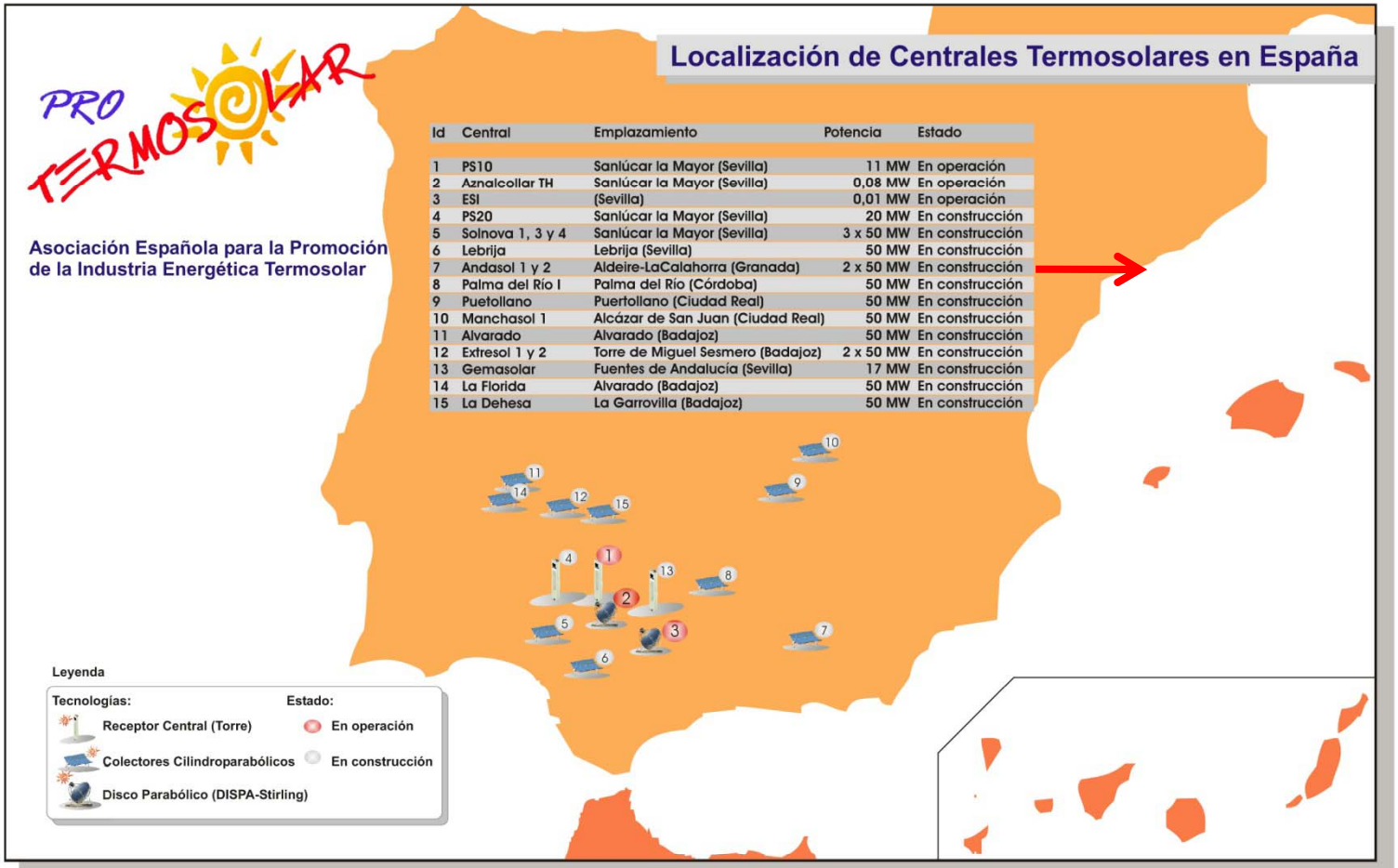
THE LARGEST 15

Localización de Centrales Termosolares en España

PRO TERMOSOLAR

Asociación Española para la Promoción de la Industria Energética Termosolar

Id	Central	Emplazamiento	Potencia	Estado
1	PS10	Sanlúcar la Mayor (Sevilla)	11 MW	En operación
2	Aznalcollar TH	Sanlúcar la Mayor (Sevilla)	0,08 MW	En operación
3	ESI	(Sevilla)	0,01 MW	En operación
4	PS20	Sanlúcar la Mayor (Sevilla)	20 MW	En construcción
5	Solnova 1, 3 y 4	Sanlúcar la Mayor (Sevilla)	3 x 50 MW	En construcción
6	Lebrija	Lebrija (Sevilla)	50 MW	En construcción
7	Andasol 1 y 2	Aldeire-LaCalahorra (Granada)	2 x 50 MW	En construcción
8	Palma del Río I	Palma del Río (Córdoba)	50 MW	En construcción
9	Puertollano	Puertollano (Ciudad Real)	50 MW	En construcción
10	Manchasol 1	Alcázar de San Juan (Ciudad Real)	50 MW	En construcción
11	Alvarado	Alvarado (Badajoz)	50 MW	En construcción
12	Extresol 1 y 2	Torre de Miguel Sesmero (Badajoz)	2 x 50 MW	En construcción
13	Gemasolar	Fuentes de Andalucía (Sevilla)	17 MW	En construcción
14	La Florida	Alvarado (Badajoz)	50 MW	En construcción
15	La Dehesa	La Garrovilla (Badajoz)	50 MW	En construcción



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ANDASOL Projects in Spain

- Size: 2 x 50 MW with 7.5 h full load storage (> 1 mio m² mirror area)
- First parabolic trough plant in -grid for Europe
- Under construction since July 2006 (Plateau of Guadix, east of Granada)
- Andasol 1 on grid since July 2008

ACS ACTIVIDADES DE CONSTRUCCIÓN Y SERVICIOS

SENER

cobra

Solar Millennium

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MENA

First Projects in a Promising Future Market

- ISCCS Plants in Morocco, Egypt and Algeria with small solar share
- Morocco and Egypt funded by GEF
- Project in Abu Dhabi in development

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Key Success Factors for a Strong Market Growth

- ❑ Technical and economical success of the first projects
- ❑ Stable green pricing or subsidies to bridge the initial gap in LECs (e.g. feed-in tariffs)
- ❑ Successful LEC-reduction
- ❑ Strong R&D to leverage the potential of technical improvement
- ❑ New markets and market opportunities (Power from North Africa to Europe)
- ❑ Strong CSP industry

LEC= Levelized Electricity Cost

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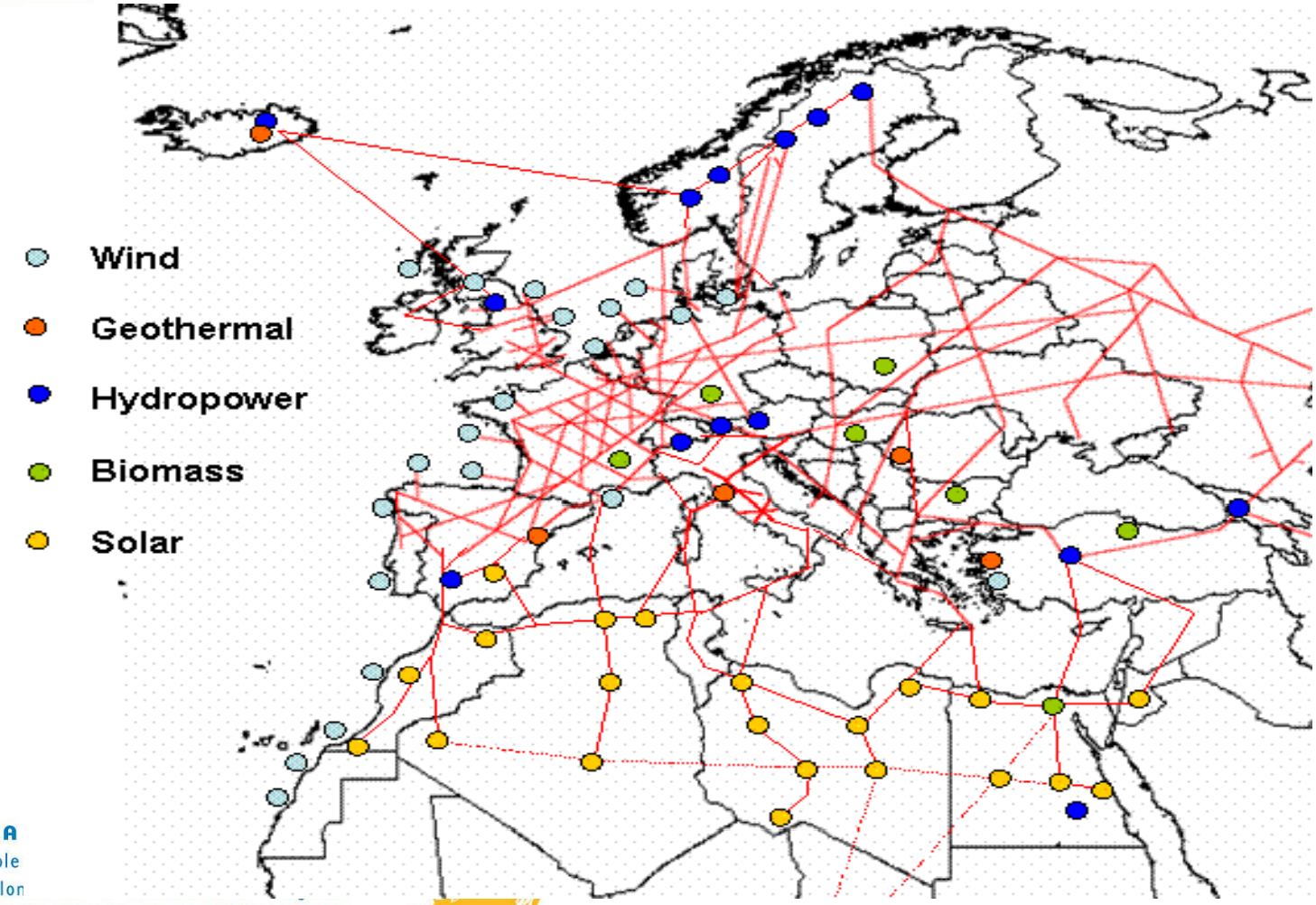
HVDC Interstate Highways for Electricity interconnecting EUMENA



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HVDC: High Voltage Direct Current Transmission

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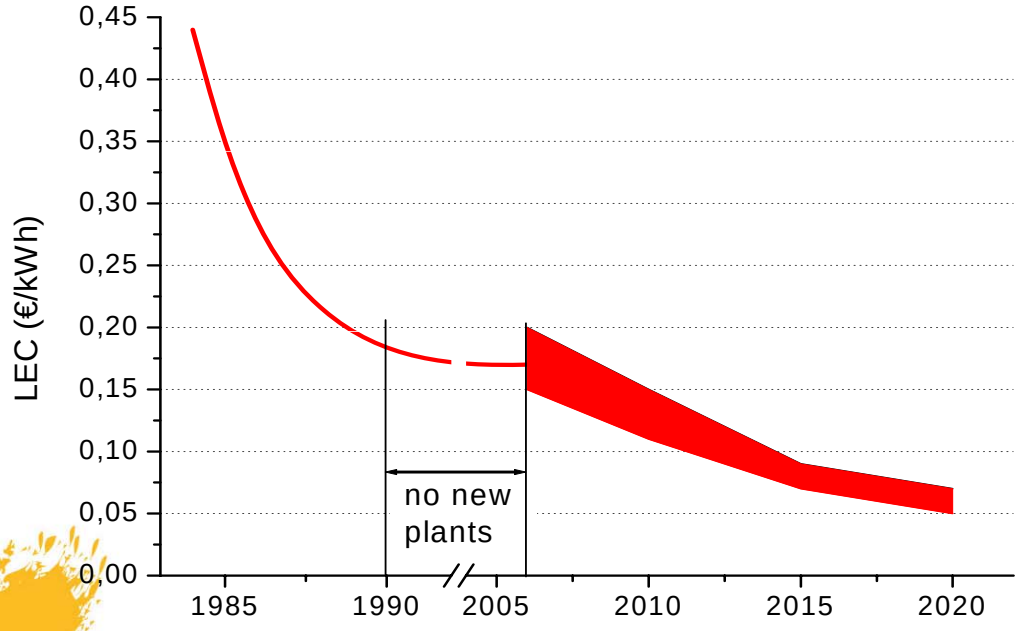
Roadmap for Parabolic Trough Plants

What brings the cost down?

- ❑ innovations in components and system, improved production technology
- ❑ improving the overall efficiency
- ❑ increasing the full load hours by using thermal storage
- ❑ bigger power blocks (economy of scale)
- ❑ reducing the O&M costs



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European Industry has head start in CSP

- Current leaders as project developers: Abengoa, Acciona, ACS-Cobra, SolarMillennium ➔ See also USA examples !
- Leaders as EPC Contractors: Abengoa, Cobra-Sener
- Leaders in critical components (“parabolic trough” receivers, mirrors, drivers, heliostates, tower receivers, I + C): Schott, Flabeg, Siemens, Sener, Abengoa
- Leaders in engineering: Sener, Flagsol, Fichtner
- Leaders in O&M: Acciona, Cobra, Abengoa

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Strategic Energy Technology (SET) Plan

OBJECTIVES

- **Reduction of generation costs**
  - **Further of the experience curve and scale factors, it can be achieved by increasing the efficiency of the overall systems and components or by implementing new concepts**

- **Enhancing the plants dispatchability,** through improvements in thermal energy storage systems and demonstration of hybrid energy concepts
  - **Combination with other renewable sources, particularly with different forms of biomass, as well as with natural gas to increase the overall system efficiency**
  - **New concepts and materials for heat storage have to be demonstrated**

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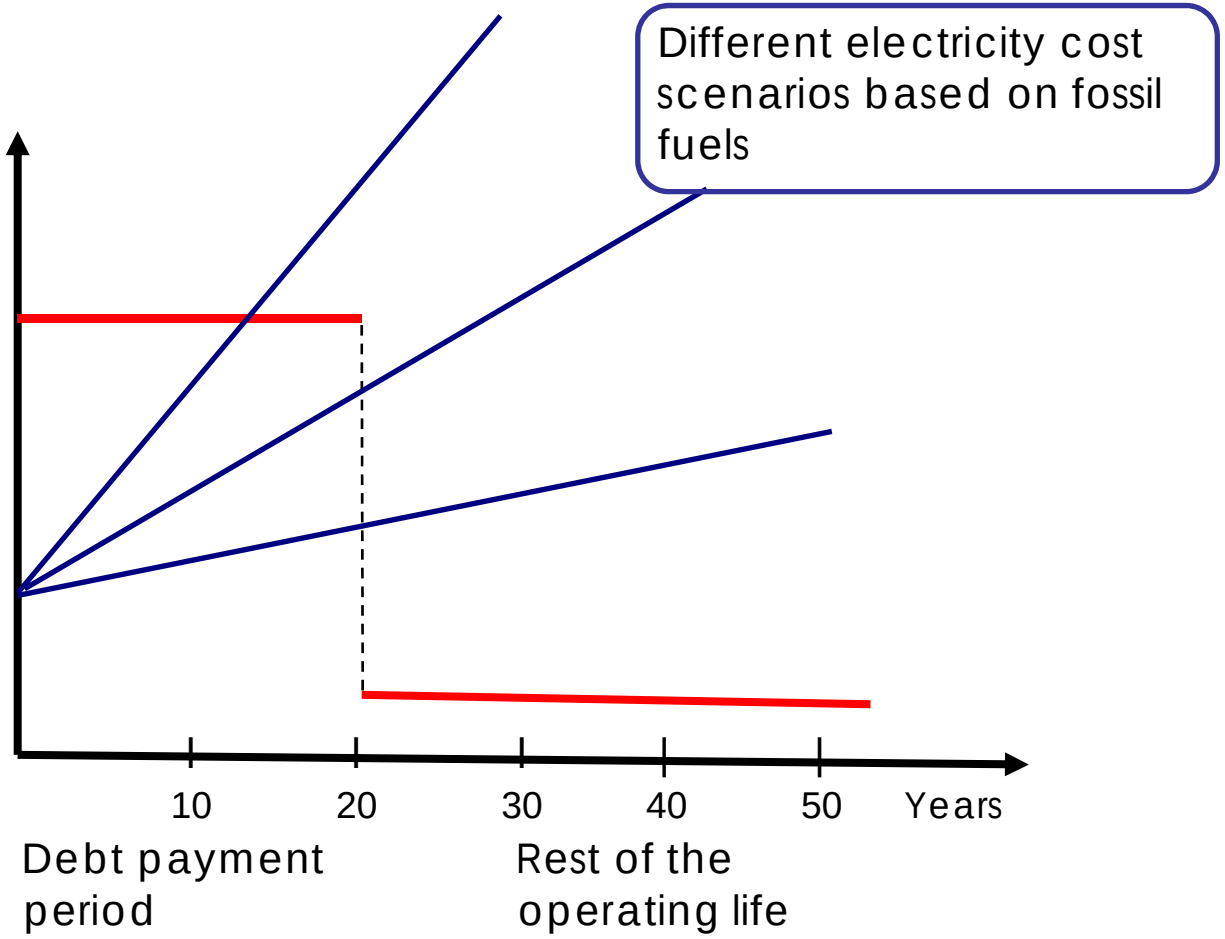
WHAT WE MEAN BY COST OF THE ELECTRICITY?

c€/kWh



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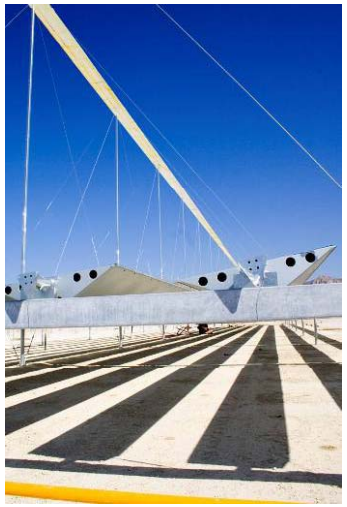
ESTELA´S PRIORITIES ON R&TD SOLAR COLLECTOR FIELDS

MAIN ISSUES



Use of land

Land requirements

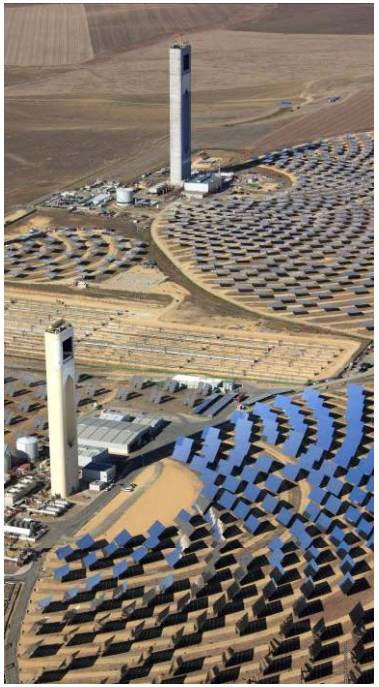
Field efficiency

Working fluid temperature

Suitable working fluids

Cost of the field

Corresponding cost of the electricity



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ESTELA´S PRIORITIES ON R&TD WORKING FLUIDS

Molten Salt

Synthetic oil

MAIN ISSUES

Highest working temperature

Freezing temperature

Heat transmission characteristics

Specific heat

Phase change characteristics

Safety issues

Cost

Air

Saturated Steam

Superheated Steam

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ESTELA´S PRIORITIES ON R&TD STORAGE SYSTEM

MAIN ISSUES

Same or different storage medium than the collector fluid
(Hydro and/or other chemicals, Bio-mass/-gas)

Single or dual media

Reversible chemical reactions

Volume

Safety issues

Cost

Hybrid systems: Complement or Alternative?

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SPAIN": 2005 - 2010

- **500 MW of installed capacity by 2010.**
- **Accumulated energy produced during the period, 2,882 GWh.**
- **Investment expected for the period = 2,163 million euros.**
- **Generation of 11,600 jobs in the 2010 horizon.**
- **483,000 tCO2 each year will stop being sent into the atmosphere from 2010 onwards**

(Comparison source: Natural Gas Combined Cycle).

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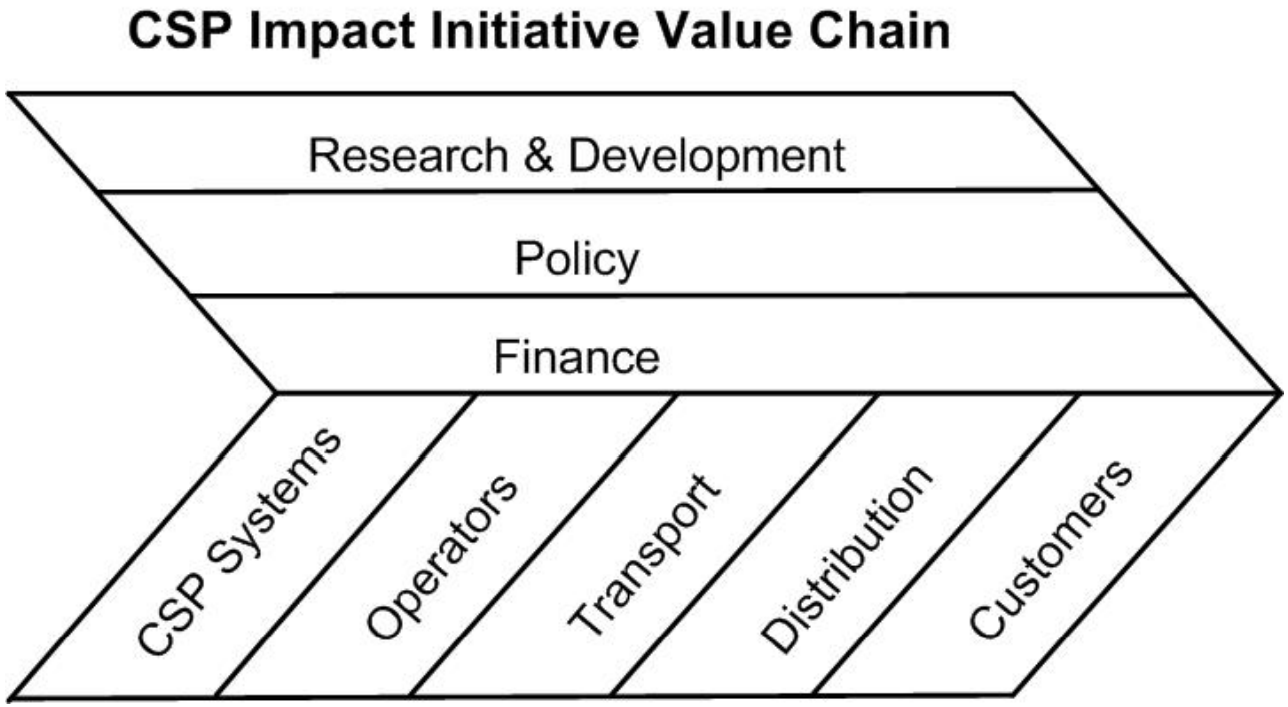
Buss. modeling important in extensive CSP implementations



How to involve all parts of the chain, cover all risks ?

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