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# Concentrating Solar Power

## Its potential contribution to a sustainable energy future

**Robert Pitz-Paal, DLR**
**Chairman of EASAC Working Group**

Friday, December 9th, 2011, Athens

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# Working Group Membership

- Professor Amr Amin, Helwan University, Egypt
- Professor Marc Bettzüge, Cologne University, Germany
- Professor Philip Eames, Loughborough University, UK
- Dr. Gilles Flamant, CNRS, France
- Dr Fabrizio Fabrizi, ENEA, Italy
- Professor Avi Kribus, Tel Aviv University, Israel
- Professor Harry van der Laan, Universities of Leiden and Utrecht, Netherlands
- Professor Cayetano Lopez Martinez, CIEMAT, Spain
- Professor Fransisco Garcia Novo, University of Seville, Spain
- Professor Panos Papagiannakopoulos, University of Crete, Greece
- Mr Erik Pihl, Chalmers University of Technology, Sweden
- Professor Robert Pitz-Paal (Chair), DLR, Germany
- Mr Paul Smith, University College Dublin, Ireland
- Professor Hermann-Josef Wagner, Ruhr-Universitat Bochum, Germany

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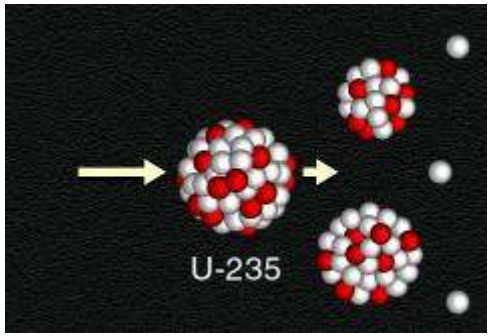
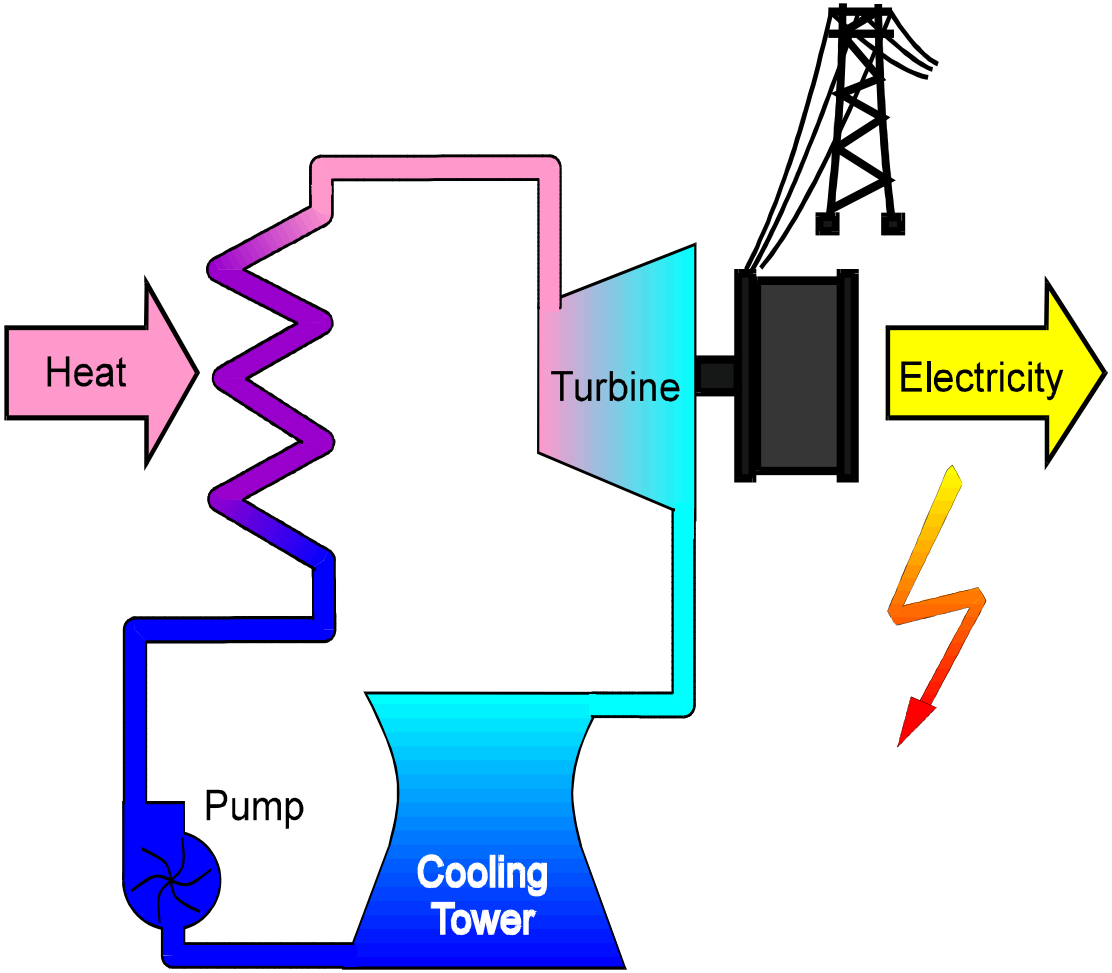
# Key Questions

- What is Concentrating Solar Power (CSP)?
- The Value of CSP Electricity
- Today's Markets and Costs
- Cost Reduction Potential
- Potential Role of CSP Technology in Europe and Middle East and North Africa (MENA)
- Challenges
- Recommendations
- Potential Benefits for Europe

# What is CSP ?

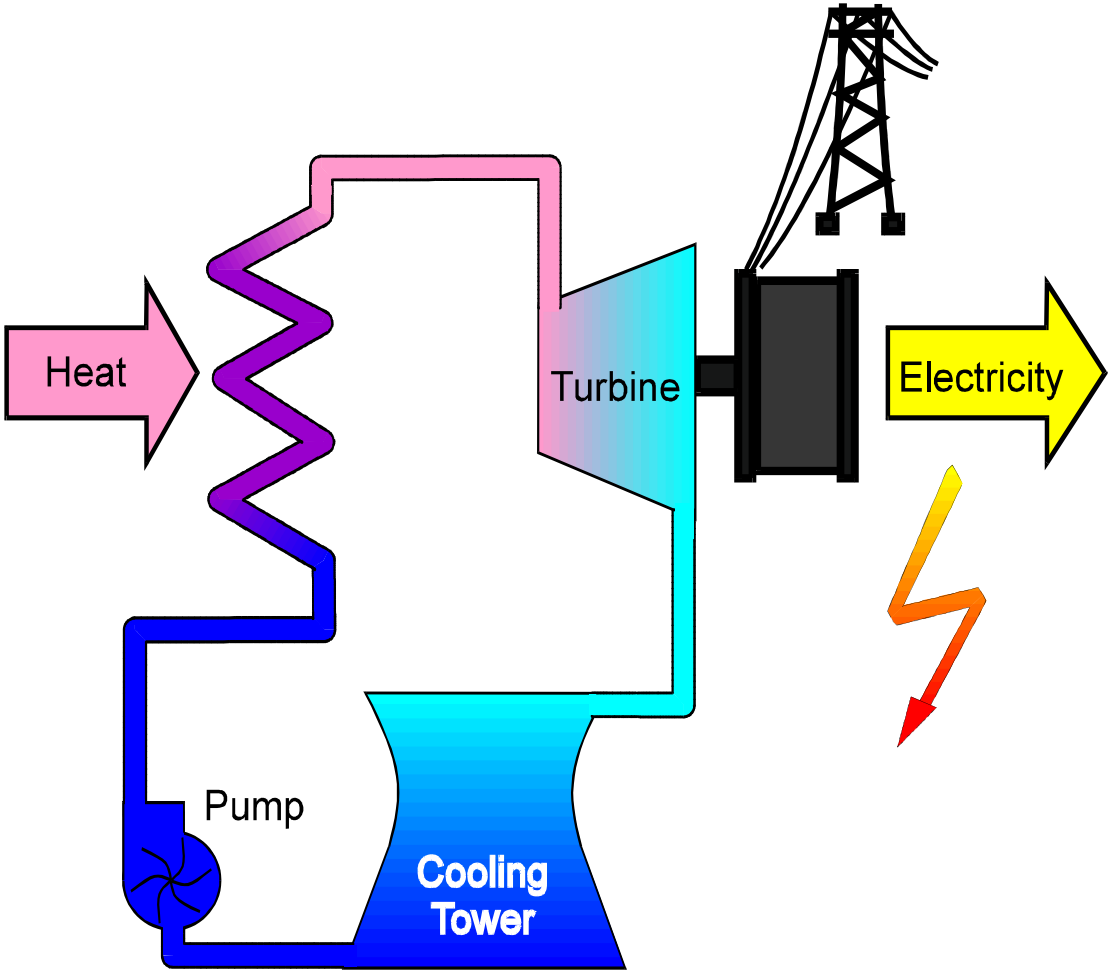



**Conventional power plants**

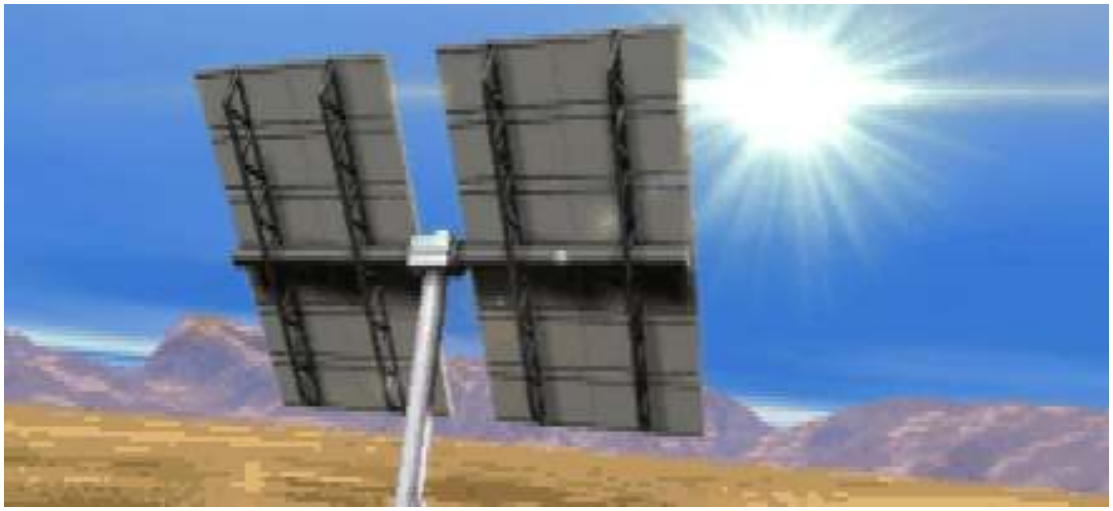


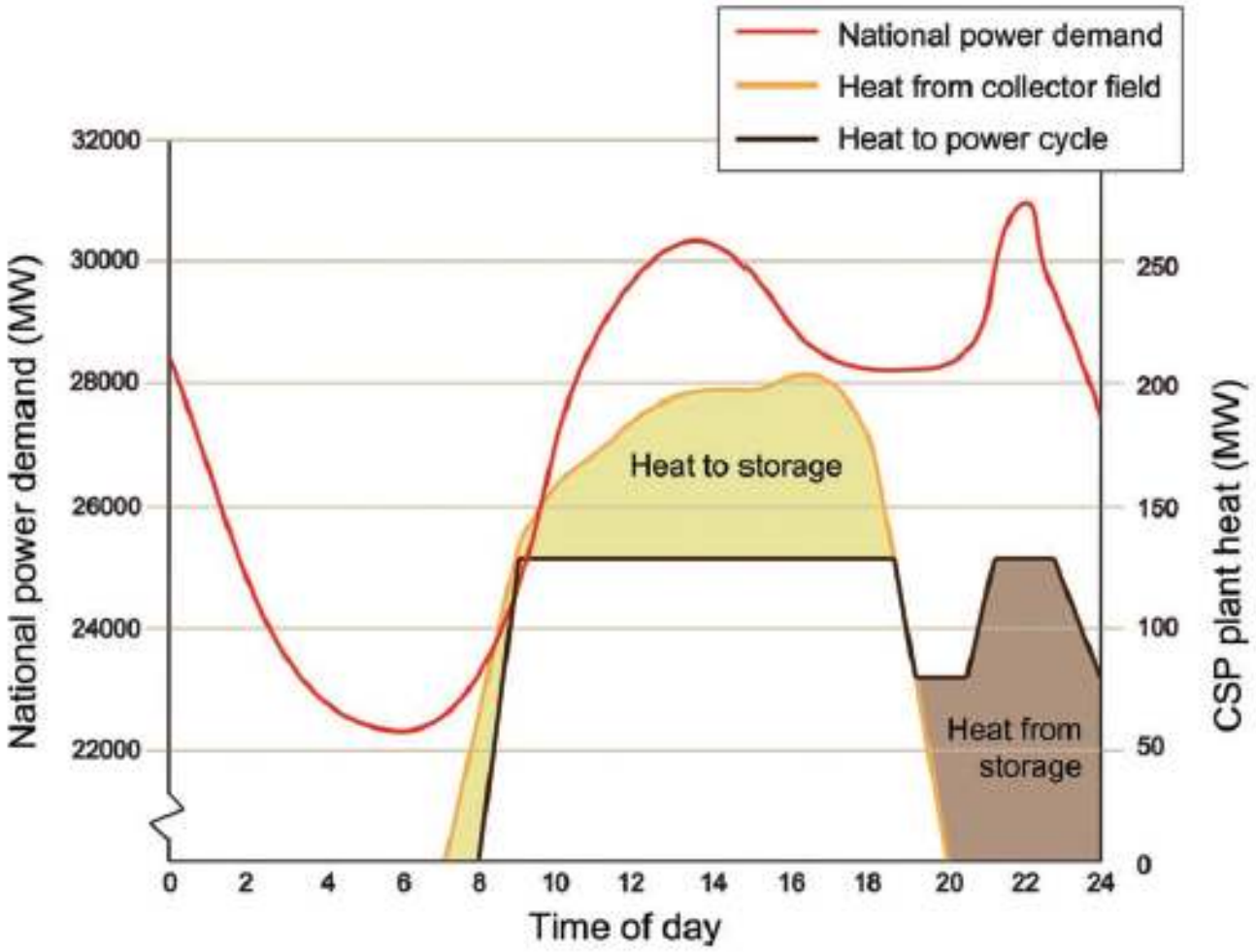
# What is CSP ?

**Solar thermal power plants**



# What is CSP?






- **Flexible Design: From peak load to base load at similar costs**
- **Thermal Storage = high efficient shift of supply**

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# The Value of CSP Electricity

**Components of value:**

- kWh's of electrical energy
- Contribution to meeting peak capacity needs
- 'Services' to support grid operation

**Conclusions:**

- Must evaluate at system level
- Value of storage increases as more variable renewables on system
- All 3 components of value can be significant
- Subsidy schemes need to reflect the price signals from competitive electricity markets
- Auxiliary firing as transition technology

# Today‘s Markets:

## Parabolic Troughs are most mature technology

# Today‘s markets:

New concepts (Tower/Fresnel) target for faster cost reduction

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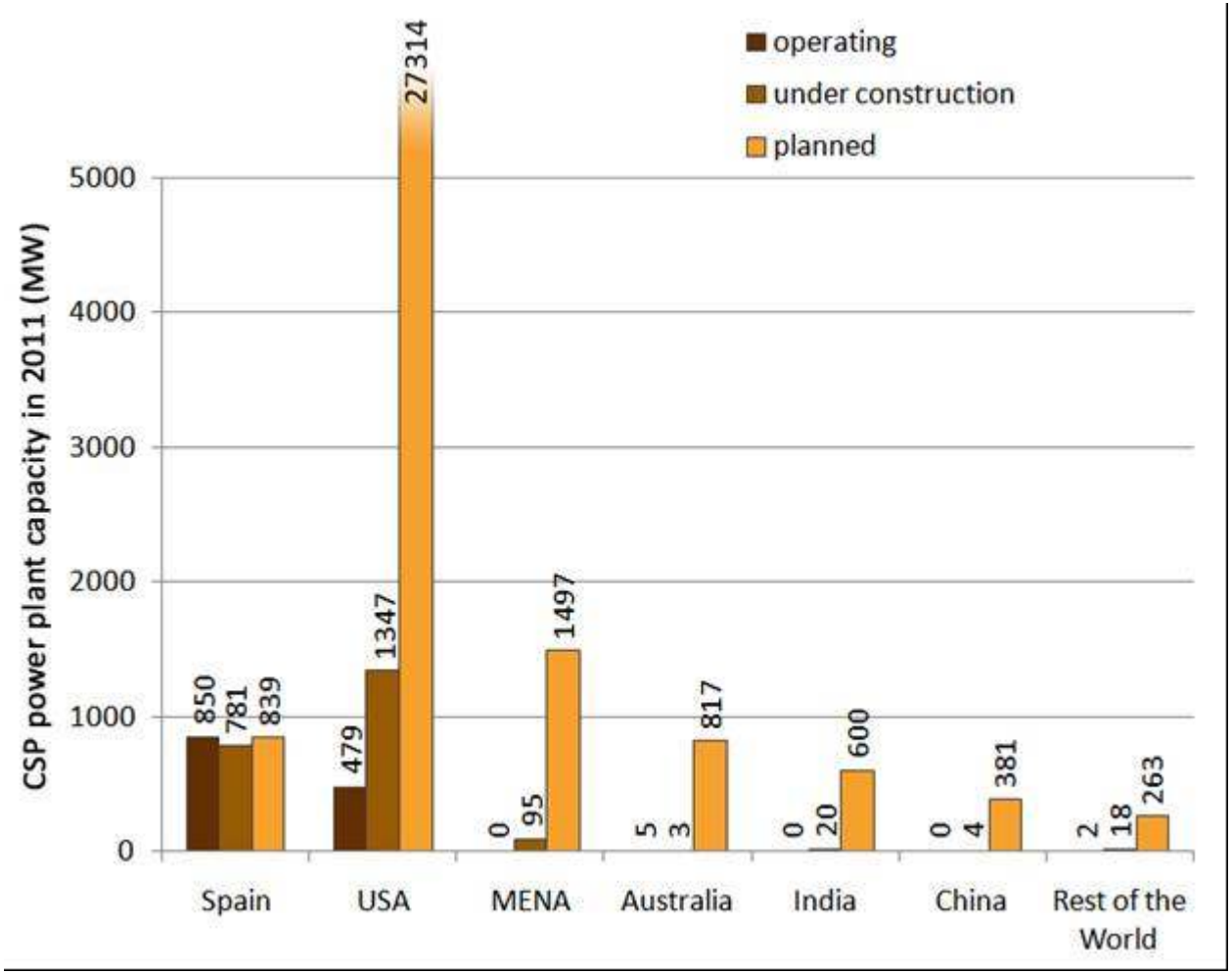
# Today's Markets



# Today's levelized cost of electricity

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| Technology | LEC €c / kWh |
|---|---|
| CSP: 100 MW w/o storage (Arizona) | 17.9 |
| Pulverized coal: 650 MW: base-load | 6.9 |
| Pulverized coal: 650 MW: mid-load | 9.0 |
| Gas combined cycle mid-load | 6.1 |
| Wind onshore: 100MW | 8.5 |
| Wind offshore: 400 MW | 15.3 |
| Photovoltaic: 150 MW (Arizona): | 21.2 |

Calculation based on Data form US Department of Energy 2010,
(Currency conversion 2010 $/€ = 0.755)

# Competition with PV and Wind

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- LEC for **onshore wind** is less than **half of CSP costs** today
- LEC for large scale **PV has dropped below CSP** in 2011
- PV and wind are **not dispatchable** – cheep electric storage is not available today
- The value of **dispatchability** depends on the system and is mostly **not reflected in the revenue schemes**
- Integration of **larges shares** of variable renewable (like wind and PV) will **increase the value of dispatchability**
- **CSP** may therefore complement / **enable larger shares** of Wind and PV in a low carbon energy system

# How to reduce costs?

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Estimates based on **detailed engineering studies**

- Mass production and scaling (25 - 30%)
- Technology improvements (20 - 30 % )

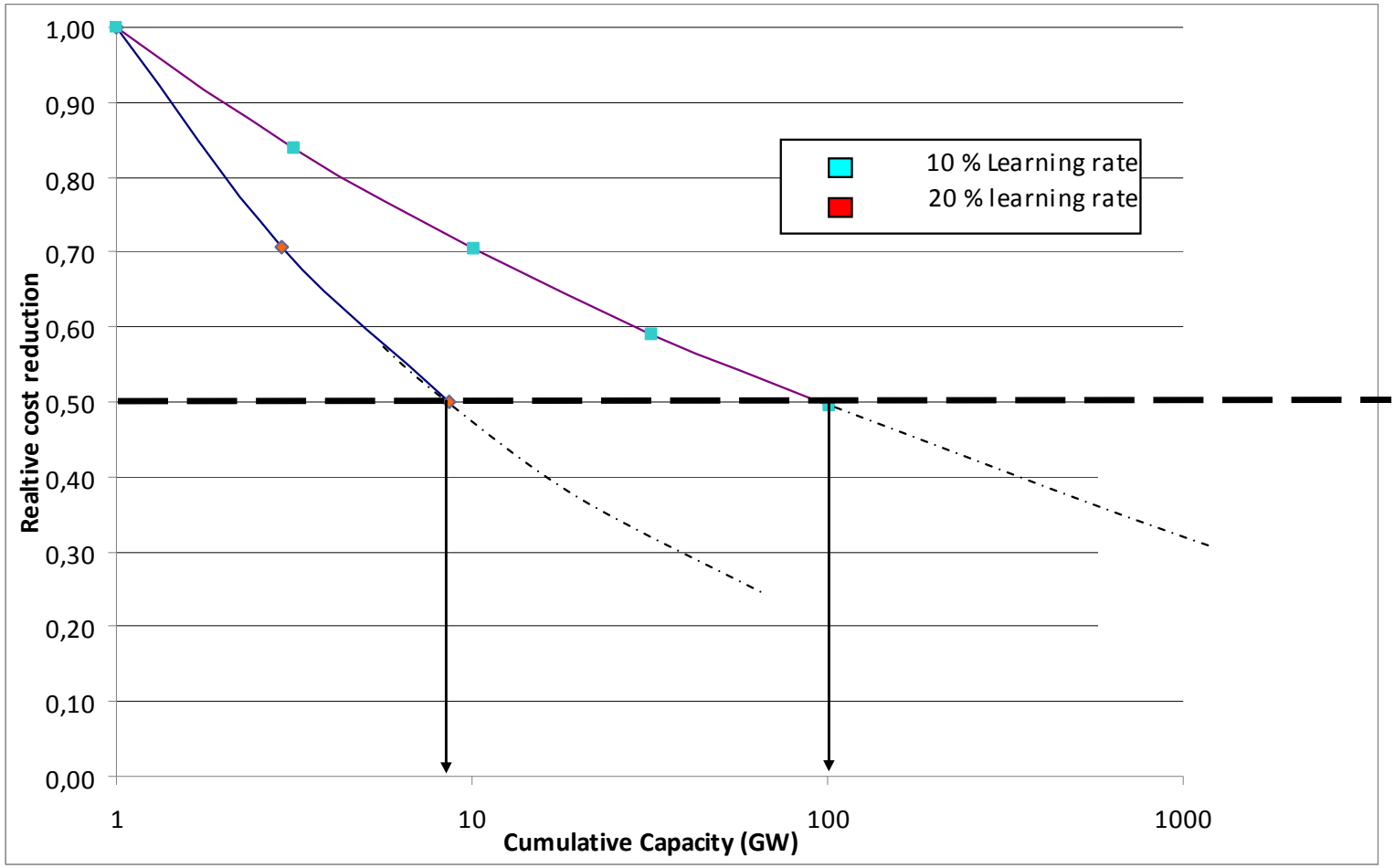
  **Breakthrough**s in
  - Front Surface Reflectors (Lifetime)
  - Heat Transfer Fluids for higher temperature (Stability and costs)
  - Advanced Solar Power Cycles (Solarized Design)
  - Storage Systems (Adaptation to Temperature and Heat Transfer Fluid)

  **LEC < 9 €cents/kWh** realistic based on technology concepts already realized in lab-scale today

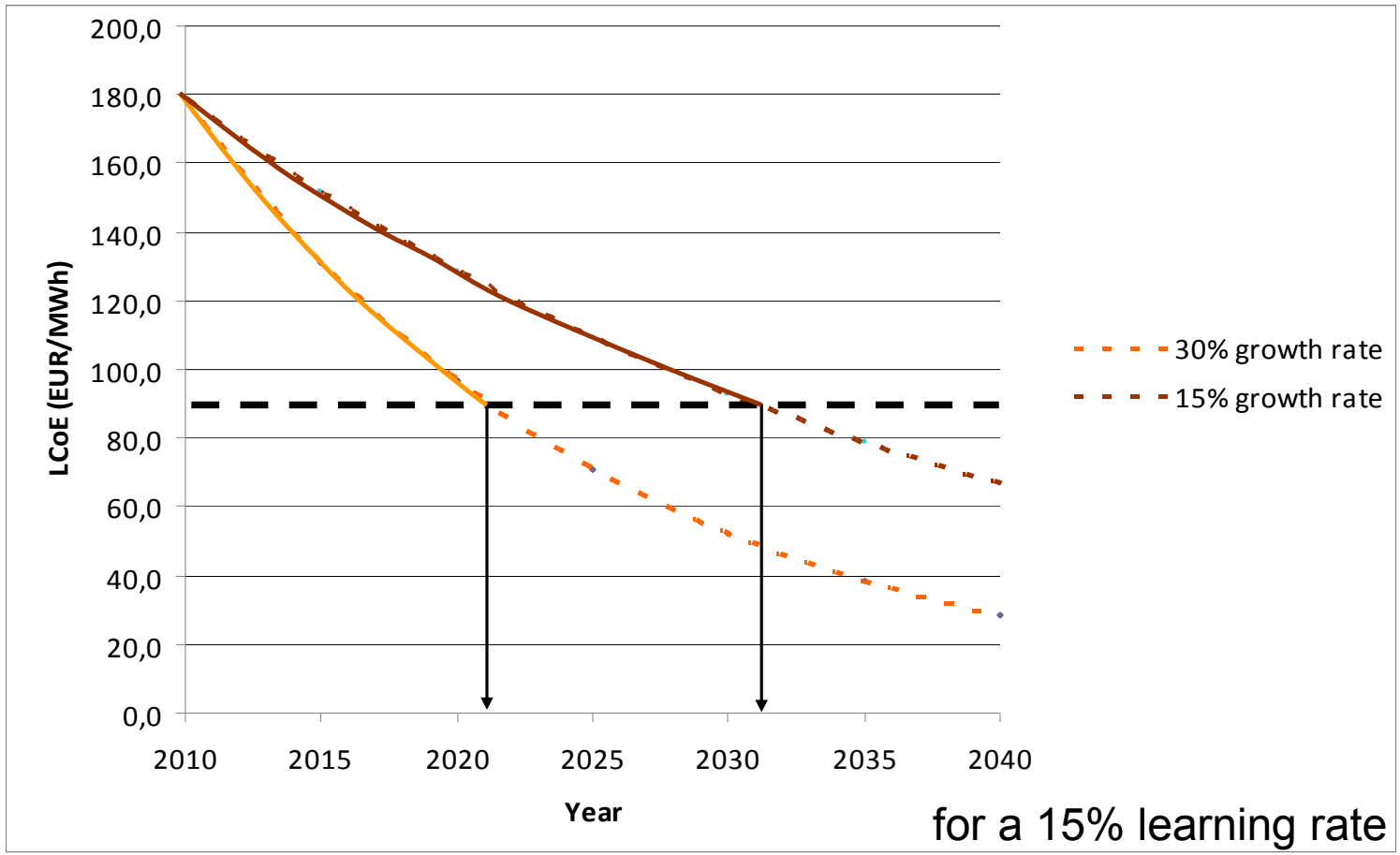
  Rate of cost reduction depends on **learning rate** and **growth rates**. The authors estimate cost breakeven with fossil fuel between 2021 and 2031

  9€cents/kWh for CO2-free dispatchable grid power is anticipated to be **competitive in some markets in 2025**

# Rate of cost reduction depends on learning rate



# and growth rate…



# Role of CSP in Europe and MENA Region

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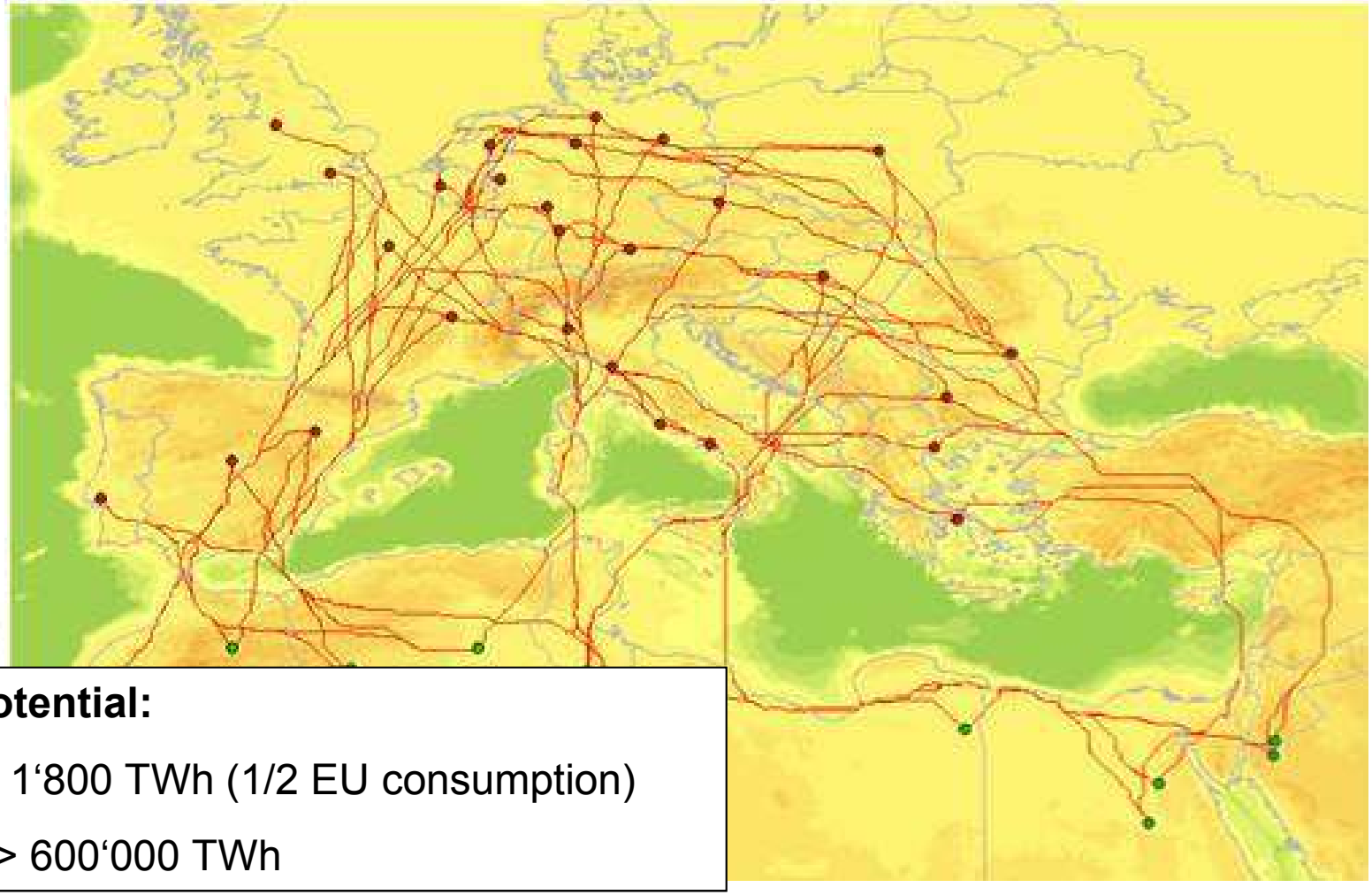

**CSP Potential:**

Europe 1‘800 TWh (1/2 EU consumption)

MENA > 600‘000 TWh

# Role of CSP in the MENA Region

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**Favourable factors:**

- Size and quality of solar resource
- Rapidly increasing indigenous demand
- Proximity to Europe and its appetite for CO2-free power
- High level of local supply share of CSP technology (up to 60% by value by 2020)

**Issues:**

- Investment conditions and ownership arrangements
- Subsidy schemes and continuity of initiatives
- Export v home use

# Challenges

- parity with fossil fuel energy in the next 10 to 15 years
- grid infrastructure and market mechanisms to integrate large fraction of CSP in southern Europe and MENA (potentially for export)
- appropriate political and economic boundary conditions in MENA to support long term investments in low-carbon technologies

# Recommendations (1/2)

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- **Incentive schemes**
  - Reflect the true **value of electricity** to the grid
  - Ensure **transparency** of cost data
  - Progressively **reduce** over time / market volume
- **R&D**
  - Ensure new technologies **progress rapidly** from laboratory, via demonstration to commercial
  - Cover fundamental research, breakthroughs and storage systems in an **integrated approach** that allows for the required scale-up and demonstration steps
  - Develop market incentivation models that favours **cost reduction by innovation** over cost reduction by mass production of state of the art technology options

# Recommendations (2/2)

- **Renewable Energy Mix**
  - Perform **system simulation studies** to evaluate the long term potential of renewables technologies in different markets and the value of dispatchability
  - Support technology development based on their **longer term potential**
- **Transformation process**
  - Identify **technical, political and socio-economic factors** necessary to achieve integration of EU and MENA energy systems
  - Direct significant **Co-funding/financing (€ Billions) by EU** as part of **neighbourhood policy** to RES / CSP project in the MENA region
  - Support **capacity building**
- **Transmission capacity**
  - Strengthen **Grid** in EU and in MENA
  - Establish **HVDC EU-MENA** links

# Benefits for Europe

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- CSP has potential to become a **zero-carbon, low-cost dispatchble electricity supplier** for southern Europe (and MENA)
- CSP can potentially **reduce** the amount of (still expensive and inefficient) **electric storage systems** (pumped hydro, CAES, Power2Gas) needed in the system
- CSP has a high local supply share creating **local value and jobs**
- Co-operation with MENA could **accelerate global climate protection** and stimulate **sustainable economic development** as part of the **neighboring policy**
- Transnational **HVDC Interconnections** (EU-MENEA) are likely to **reduce the overall transformation costs** of the Energy System