# Economic Diversification and Sustainable Development *Facts and thoughts*

16 May 2006

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International Energy Agency

# Outline

- Economic Diversification: the need for it does not arise only from measures to mitigate climate change
- Economic Diversification and Sustainable Development: Implications for energy
- A focus on solar power

# Economic Diversification

- Natural resource endowments:
  - A chance or a curse? A challenge!
- Exhaustible resources:
  - By definition, do not last for ever
- Dependence:
  - When too strong, a problem for producers as well as for consumers
  - How strong is too strong?

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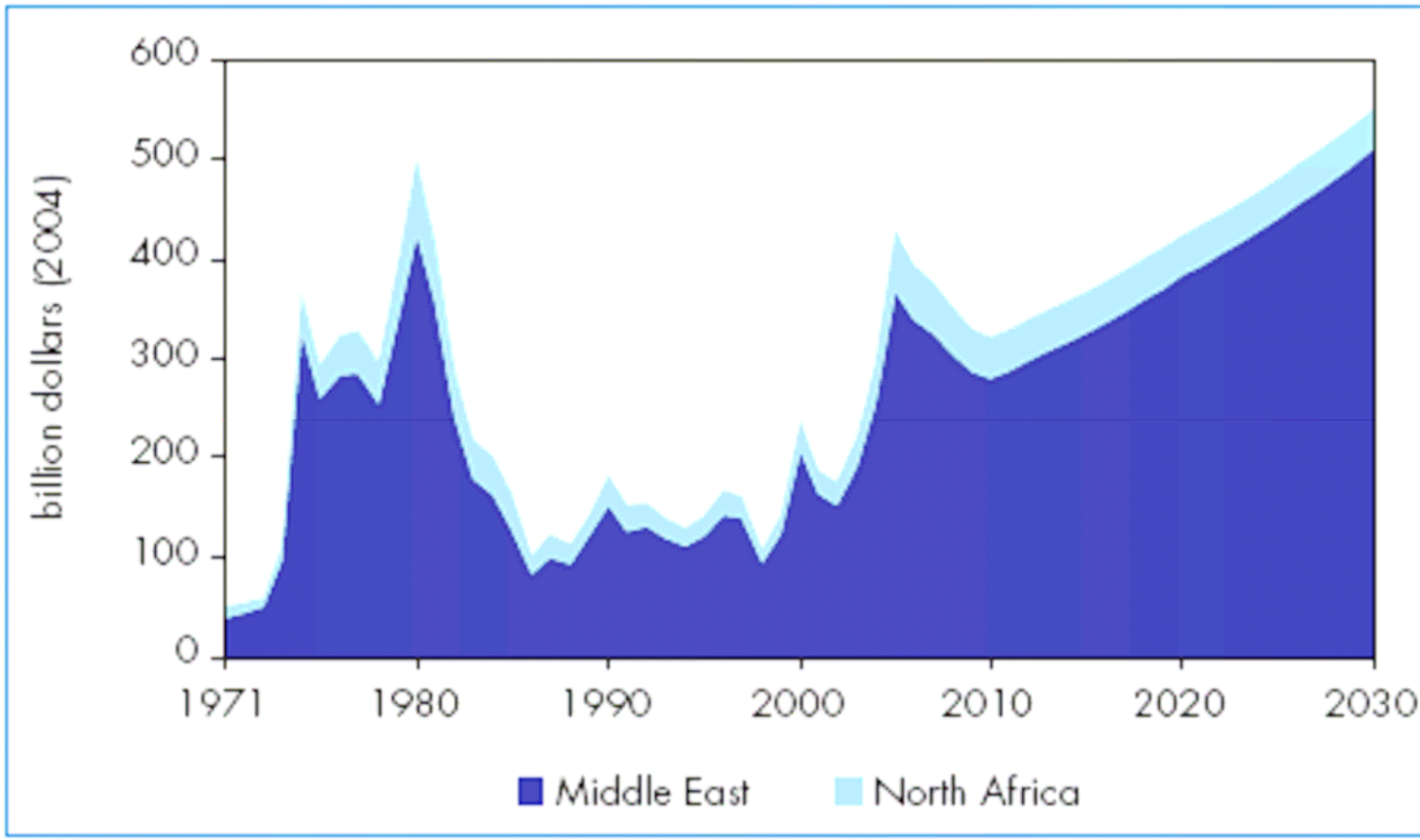
# Oil export revenues will increase…

*Figure 3.6:* MENA Oil Export Revenues



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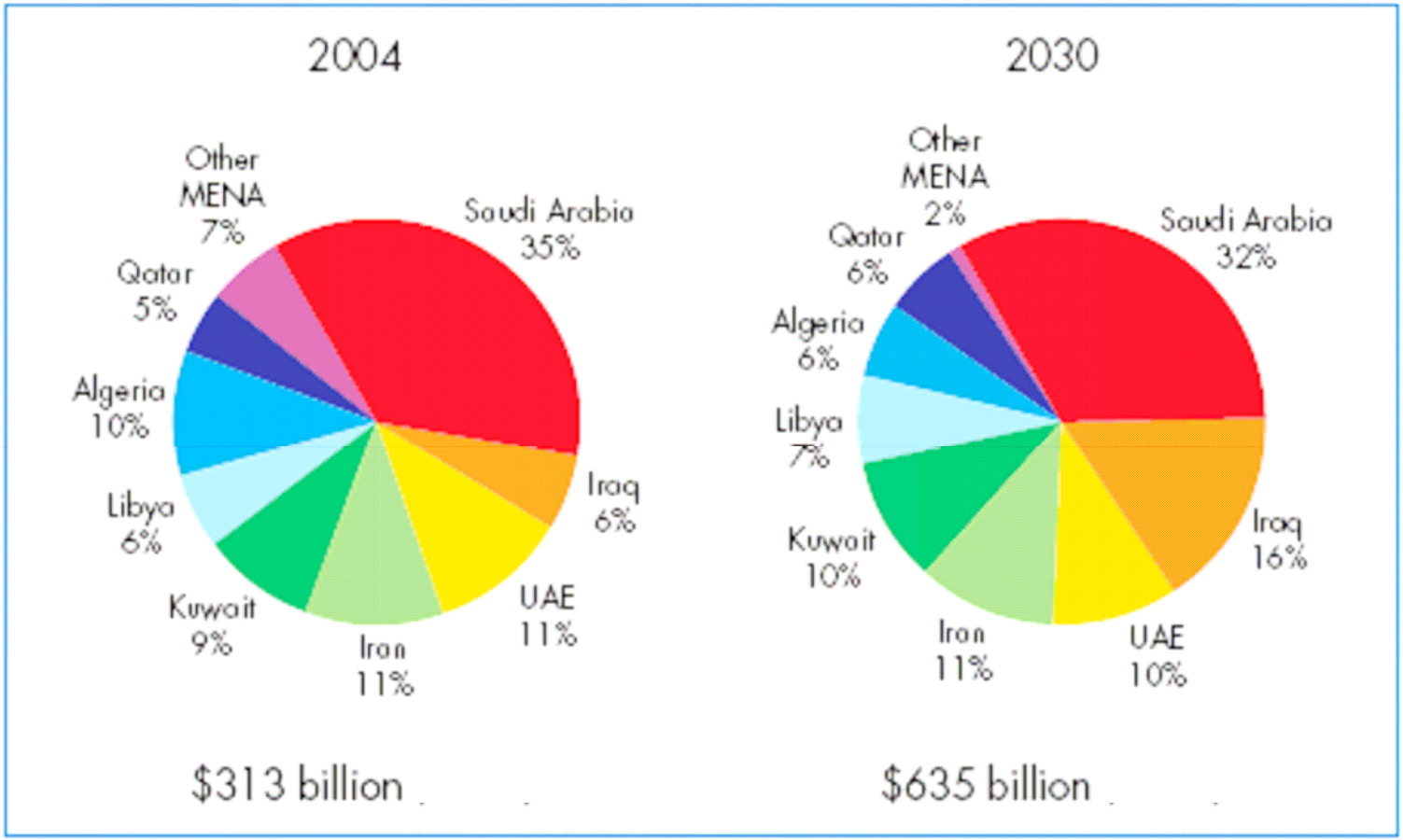
# Oil and gas revenues

*Figure 3.5:* MENA Oil and Natural Gas Export Revenues, Share by Country



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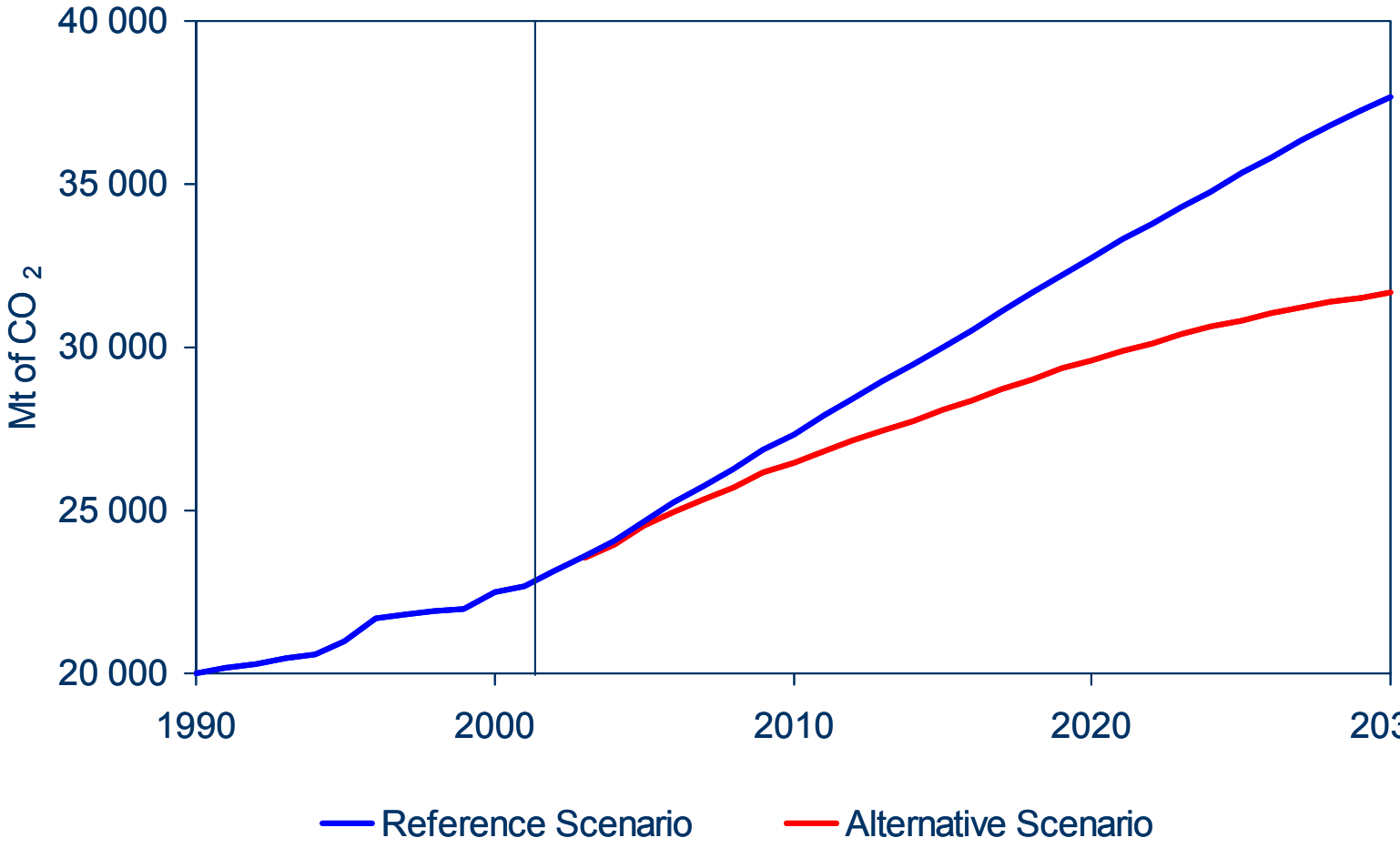
# Global CO2 Emissions in the Reference & the Alternative Scenarios



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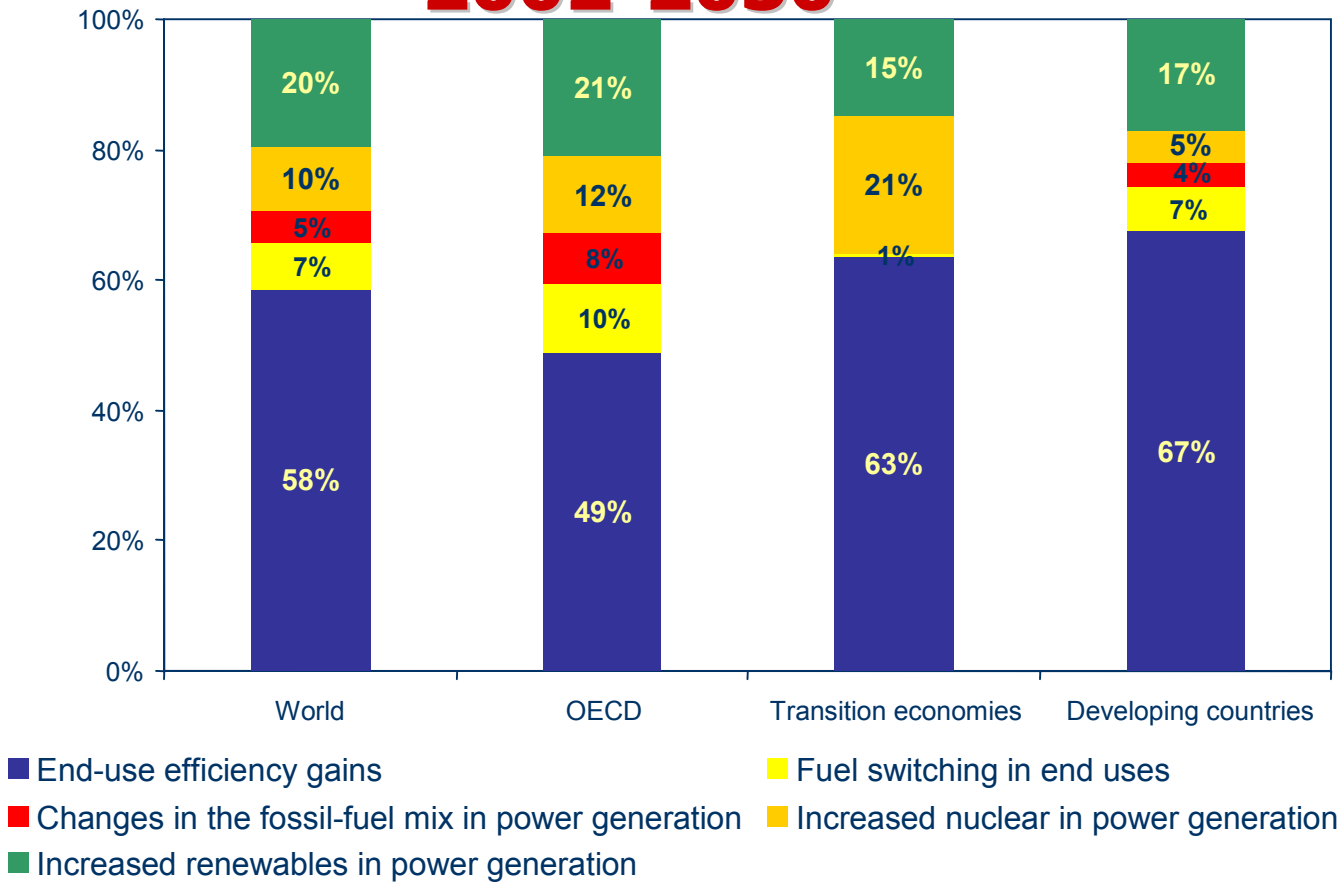
# Contributory Factors in $CO_2$ Reduction, 2002-2030




**Improvements in end-use efficiency contribute for more than half of decrease in emissions, and renewables use for 20%**

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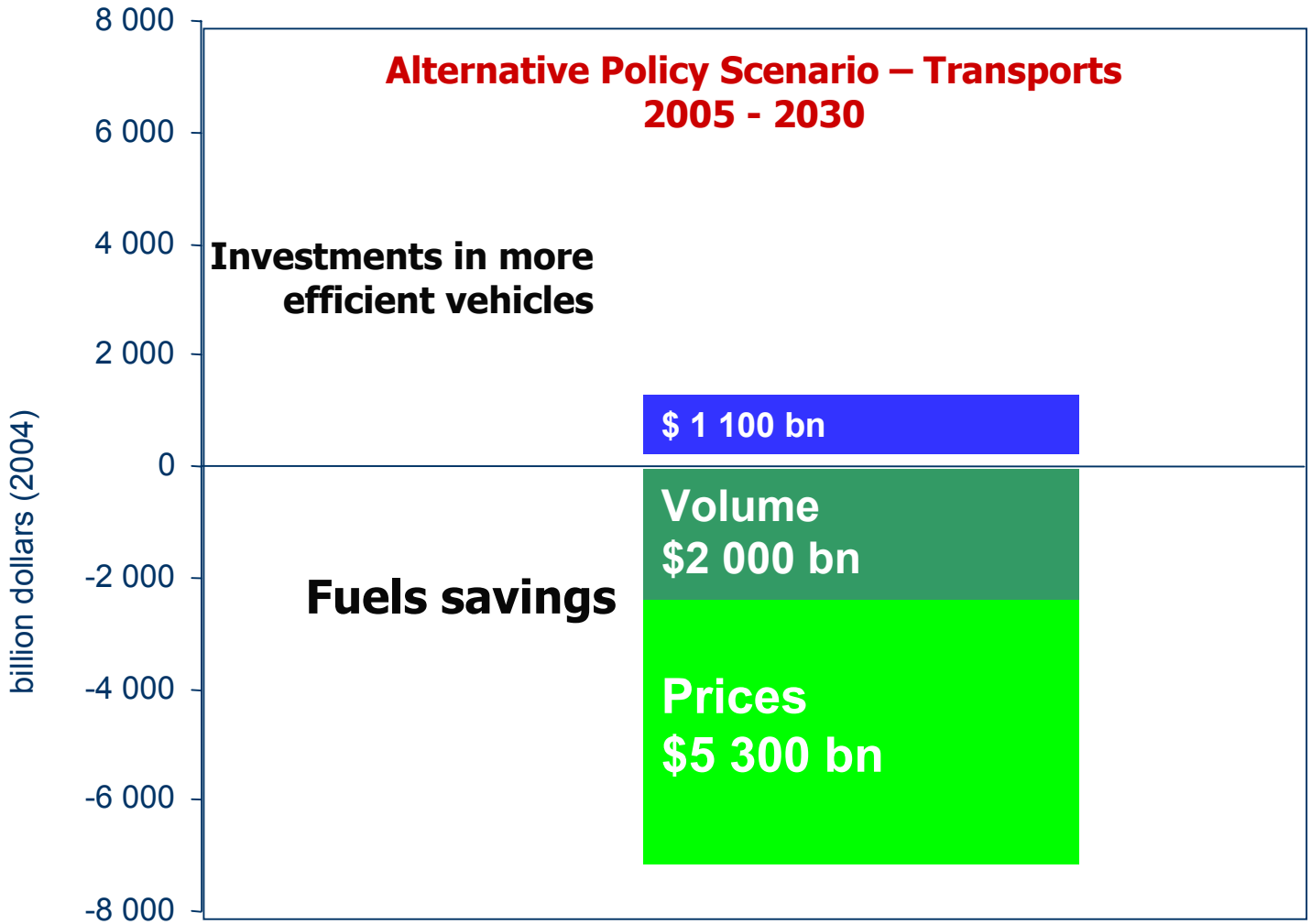
# Energy Efficiency may impact volumes of trade and prices



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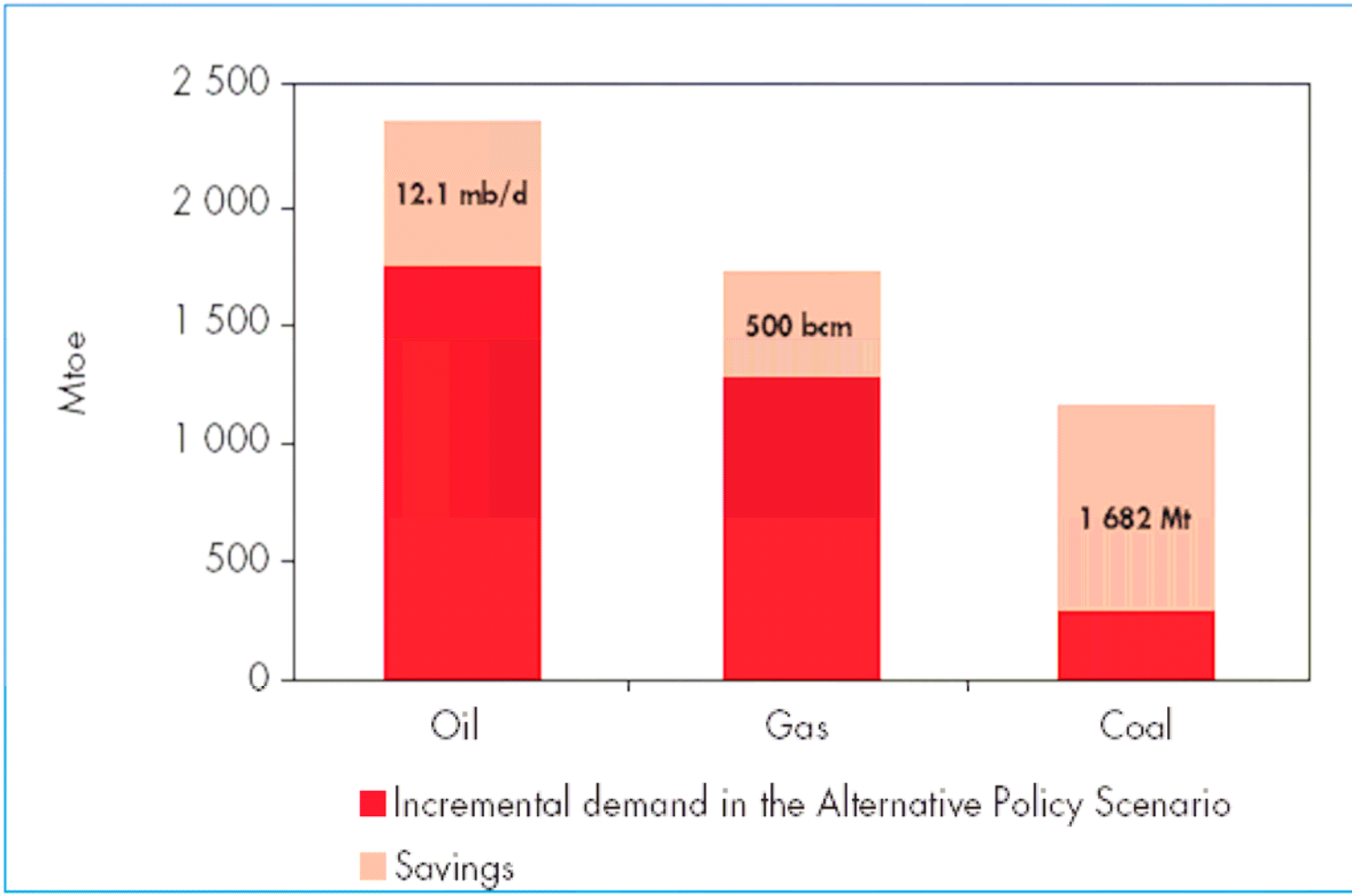
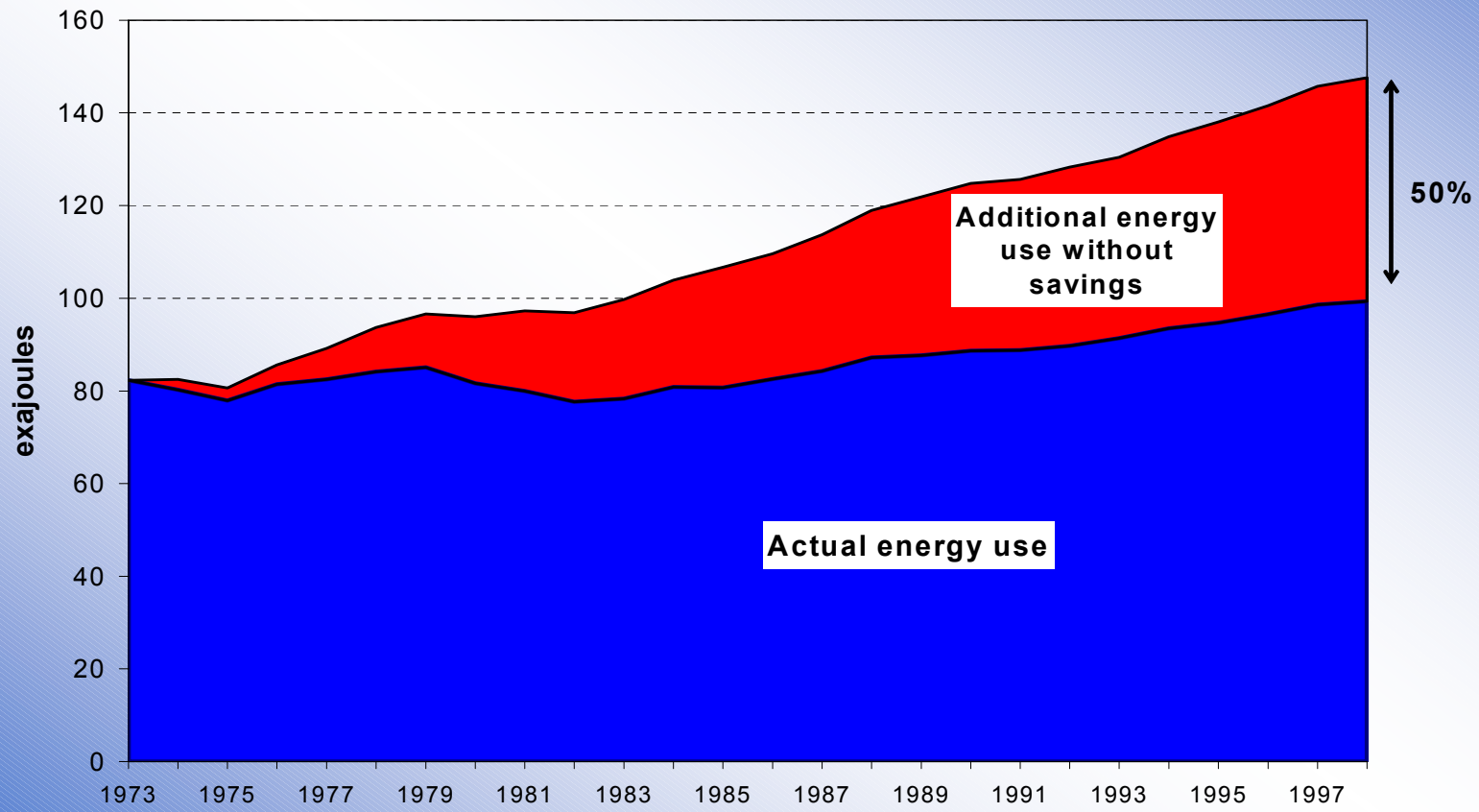
# Oil, Gas and Coal Demand Growth in the Alternative Scenario & Savings Relative to the Reference Scenario, 2003-2030




***Oil & gas demand in the Alternative Scenario are both 10% lower in 2030 due to significant energy savings and a shift in the energy mix***

# But energy saving policies predate climate policies…

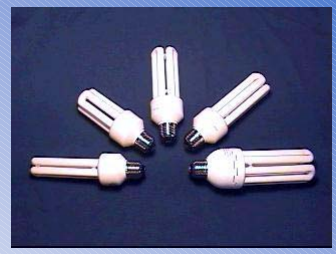
## AIE -11



# … and have many motives

High performance buildings

- substantial energy and greenhouse gas savings at low or negative cost
- energy security benefits
- enhanced business competitiveness and social welfare
- *The cheapest, cleanest and safest way of addressing all our goals is to use less energy" – UK White Paper*



Compact Fluorescent Lamps

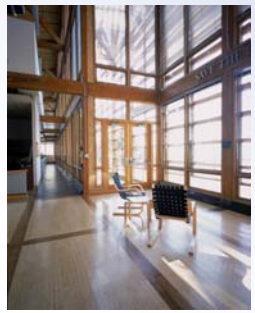
Least life-cycle cost appliances

LED traffic lights


Labelling and certification

Efficient information and communication technologies

Reducing standby power consumption



Super windows & daylighting

# Economic Diversification did not wait for the UNFCCC either…

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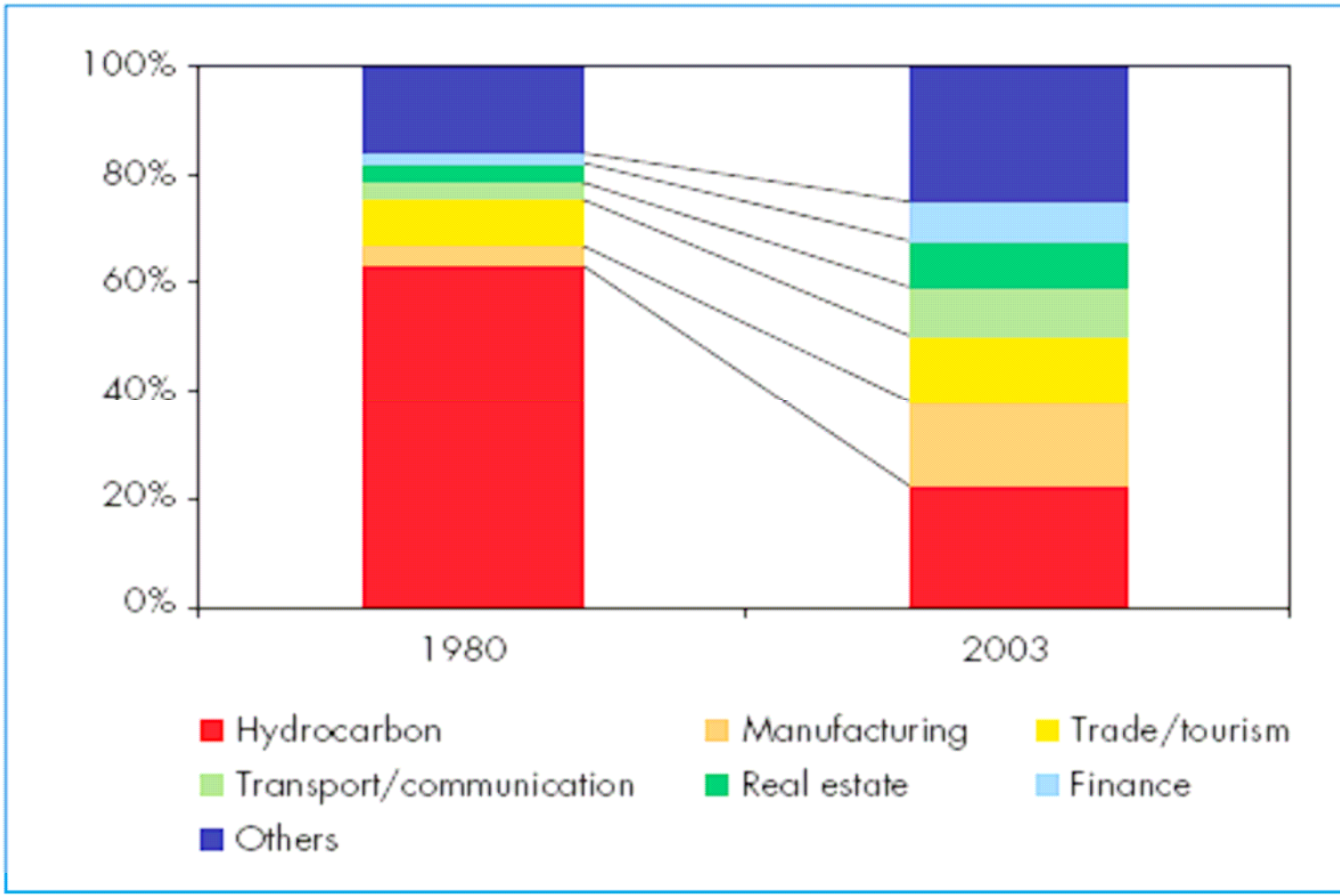
*Figure 17.1:* Share of GDP by Sector in the UAE




Sources: Ghanem (2001); Central Bank of the UAE (2004).

# Diversification within the energy sector

- More downstream activities (refining, petrochemicals…)
- Coal-to-liquid and gas-to-liquid
  - Climate-friendly *if the CO2 is captured and stored*, but not sustainable in the very long term, although CCS and EOR may help delay exhaustion
- Overall, may not decrease *« the dependence on income generated from the production, processing and export and/or consumption of fossil fuels… »* (UNFCCC)

# Sustainable development

- A pragmatic approach: the Hartwick rule (1977)
  - Rents from exhaustible resources must be invested in substitutes
- May not work for species or ecosystems, but seems working for fossil fuels
  - Substitutes exist that are inexhaustible and climate-friendly…
  - … and can reduce dependence on fossil fuels exports or consumption

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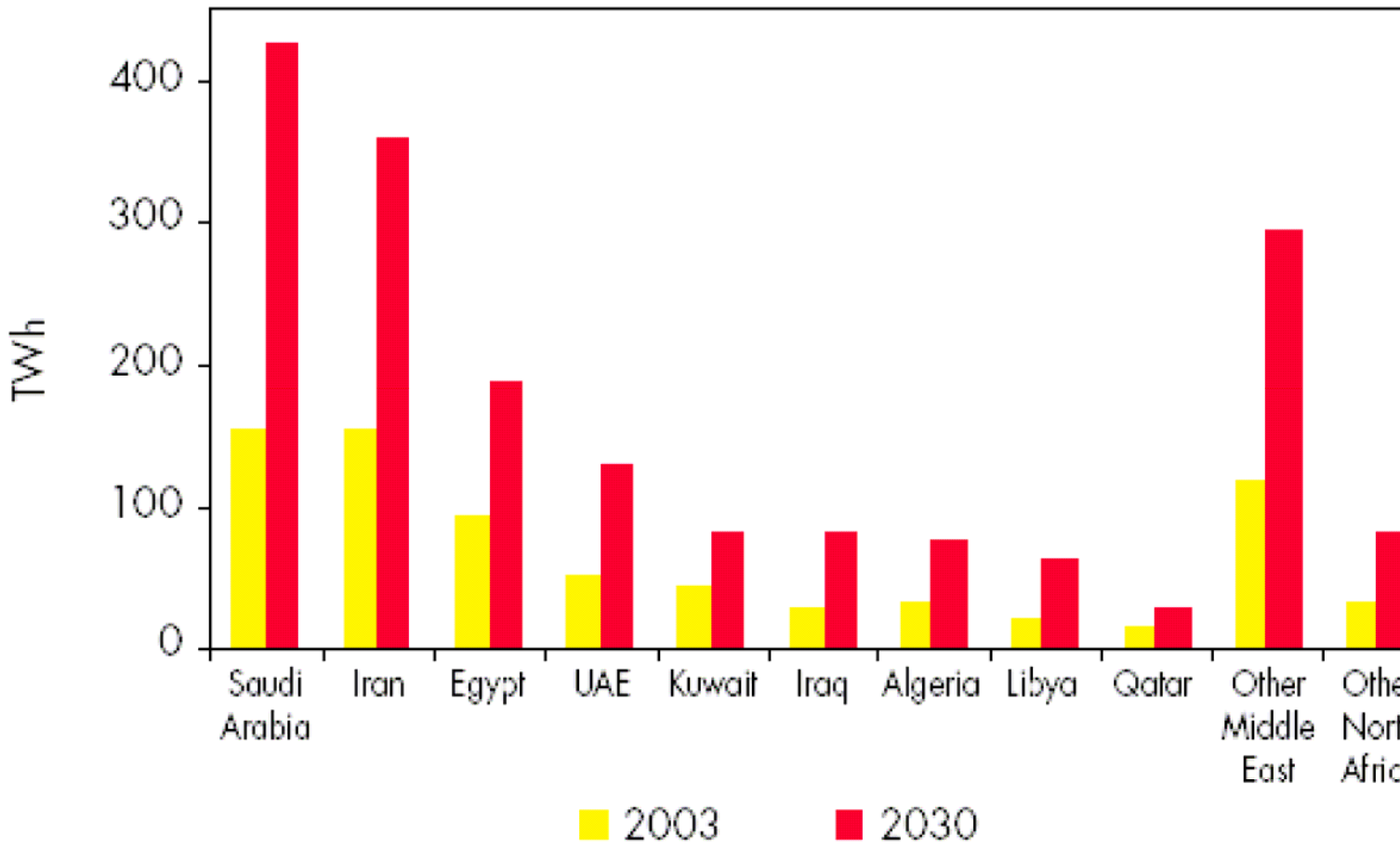
# Increases in electricity demand



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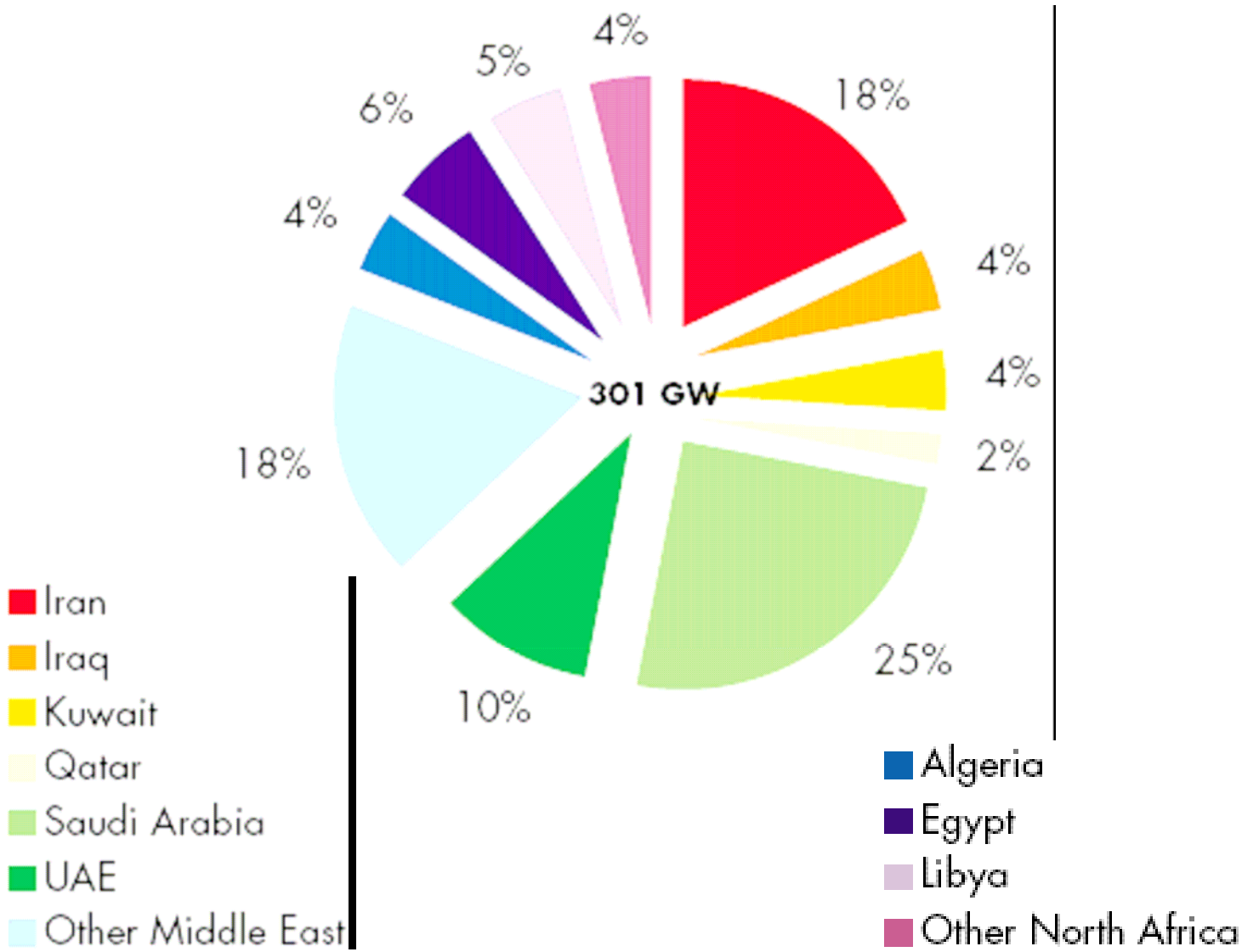
# Capacity additions



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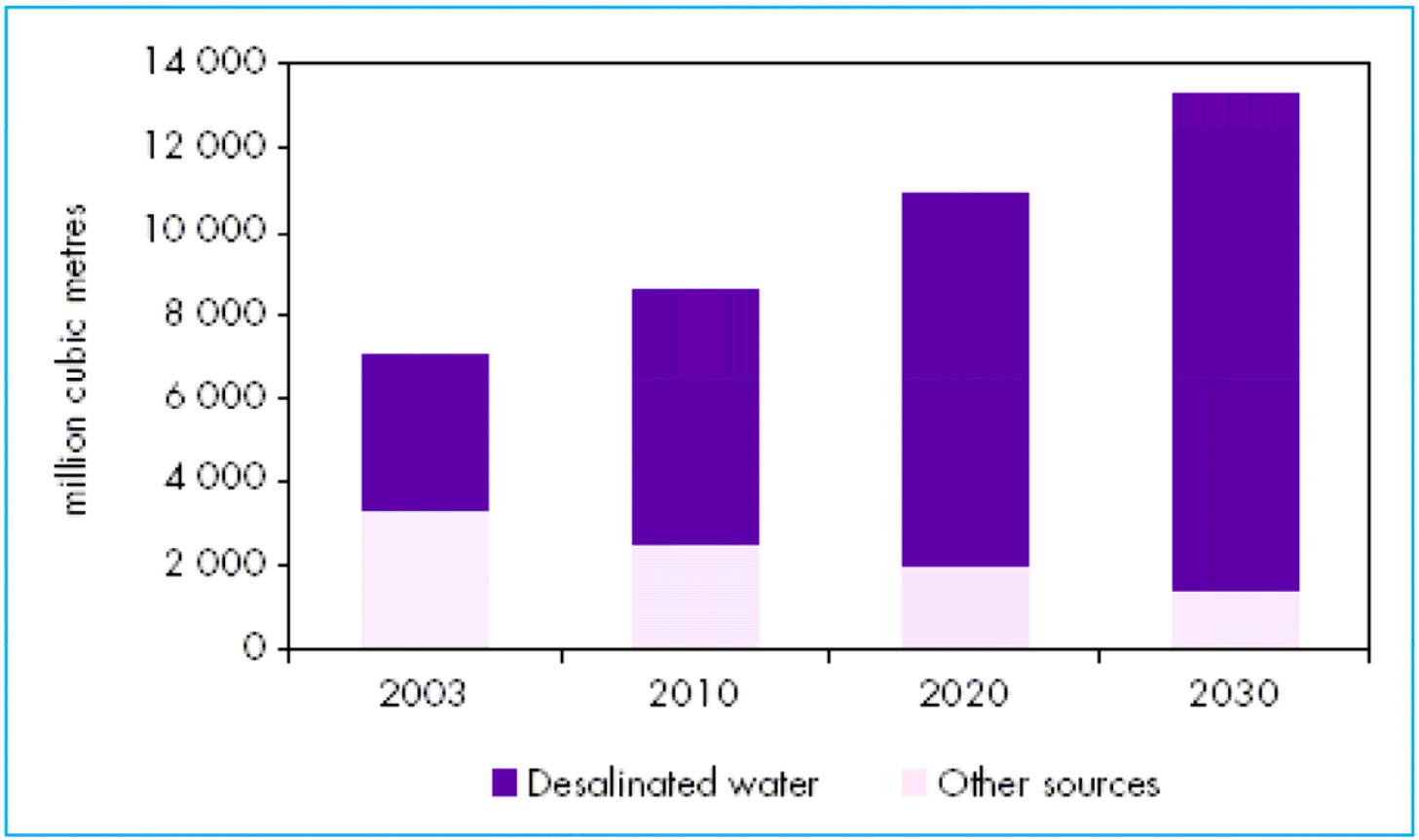
# Fresh Water Scarcity

*Figure 6.21:* Water Demand* in Saudi Arabia, Kuwait, the UAE, Qatar, Algeria and Libya




* Projections do not include water demand in the agricultural sector.

From fossil waters to waters desalinated with fossil fuels?

# Renewables

- Biomass and waste about 11% of total primary energy supply (TPES)
  - Not always renewable, often unhealthy use
  - Space occupation may limit biomass
  - *IEA/ADB modern biomass Nairobi, 3-6 October*
- Hydro about 2.3% world TPES (16% world electricity)
  - But additional capacities face social and environmental concerns
- Others: less than 1% world TPES
  - Rapid growth of wind energy
  - Issues of costs and intermittence
- Solar potential is considerable

# Solar potential

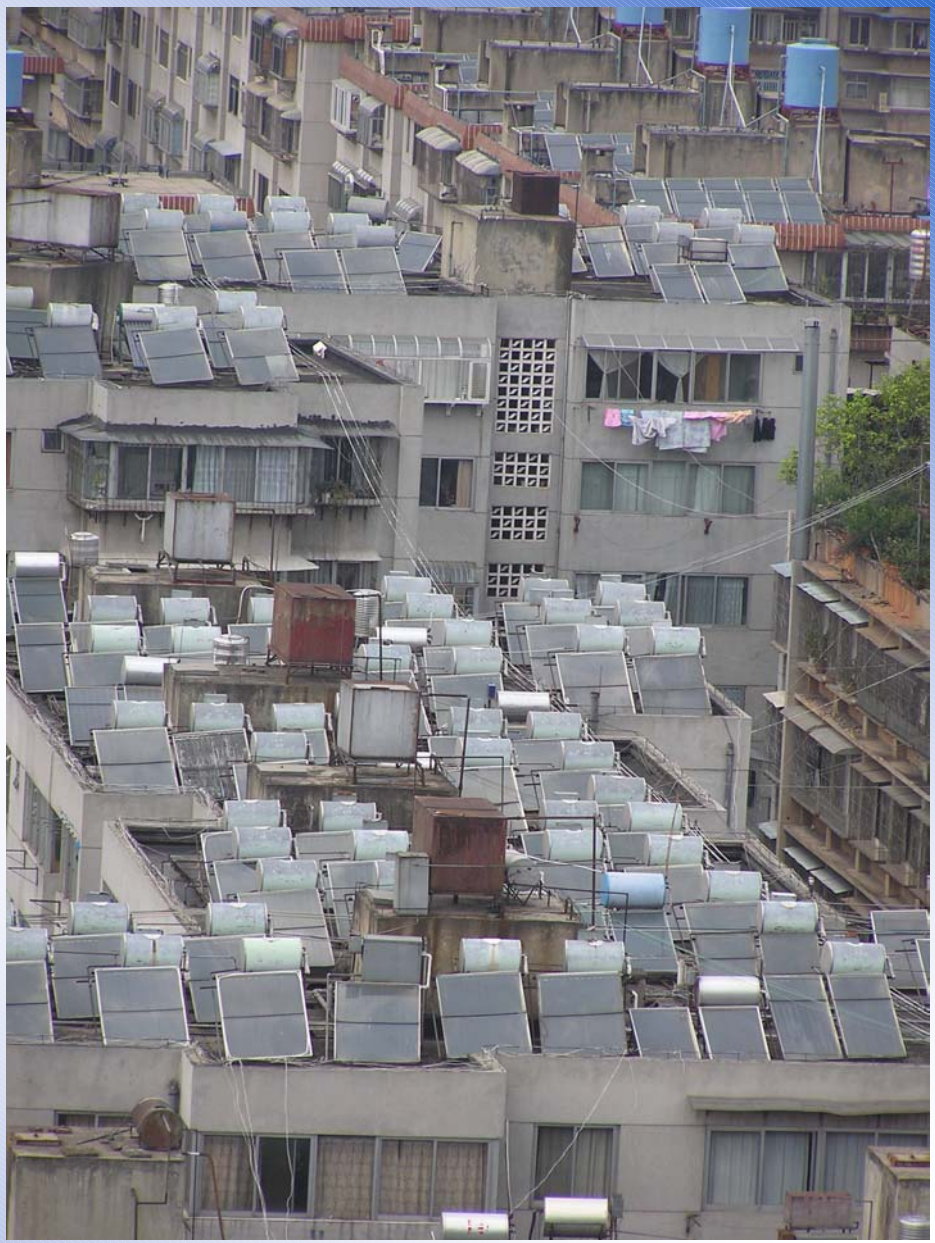
- Total primary energy supply (TPES) in 2002: 433 Exajoules (Ej), equivalent to 13.75 TW of continuous power
- TPES of about 688 Ej, or 21.8 TW in 2030
- Solar radiation on Earth's surface 120,000 TW - 8,000 times TPES.
- Fulfilling TPES needs covering about 0.6% of emerged lands with 10% net efficient solar conversion systems.

# Solar thermal technologies

- Low temperature
  - Sanitary hot water, heating, cooling, drying
  - Passive: Solar architecture
  - Active: Solar panels
- Thermal uses absorb about 40% of TPES
  - Mostly as low temperature heat
- High temperature
  - Industrial process, power, desalination, fuels
  - Concentrating solar power

# Solar Panels

**Installed capacity 140 million $m^2$ - 100 GWth**
**Increase was 13 million $m^2$ in 2004 – of which 10 million in China!**



# Solar Heat for Industries

(• : important, X: very important)

| process | food | textile | building material | galvanizing, electroplating | fine chemicals | pharmaceutical and biochemical | service industry | paper industry | automobile supply | tanning | painting | wood and wood products |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| cleaning | X | X | • | X | • | X | X | | • | • | X | |
| drying | X | X | • | | • | X | X | • | • | X | X | X |
| evaporation and distillation | X | | | | • | X | | | | | | |
| pasteurisation | X | | | | | X | | | | | | |
| sterilization | X | | | | | X | | | | | | |
| cooking | X | | | | | | | | | | | |
| general process heating | • | • | • | X | • | • | X | | • | | | • |
| boiler feed water preheating | X | X | • | | • | • | | • | | • | | |
| heating of production halls | X | X | | • | • | • | • | | X | X | X | X |
| solar absorption cooling | X | | | • | | X | X | | | | | |

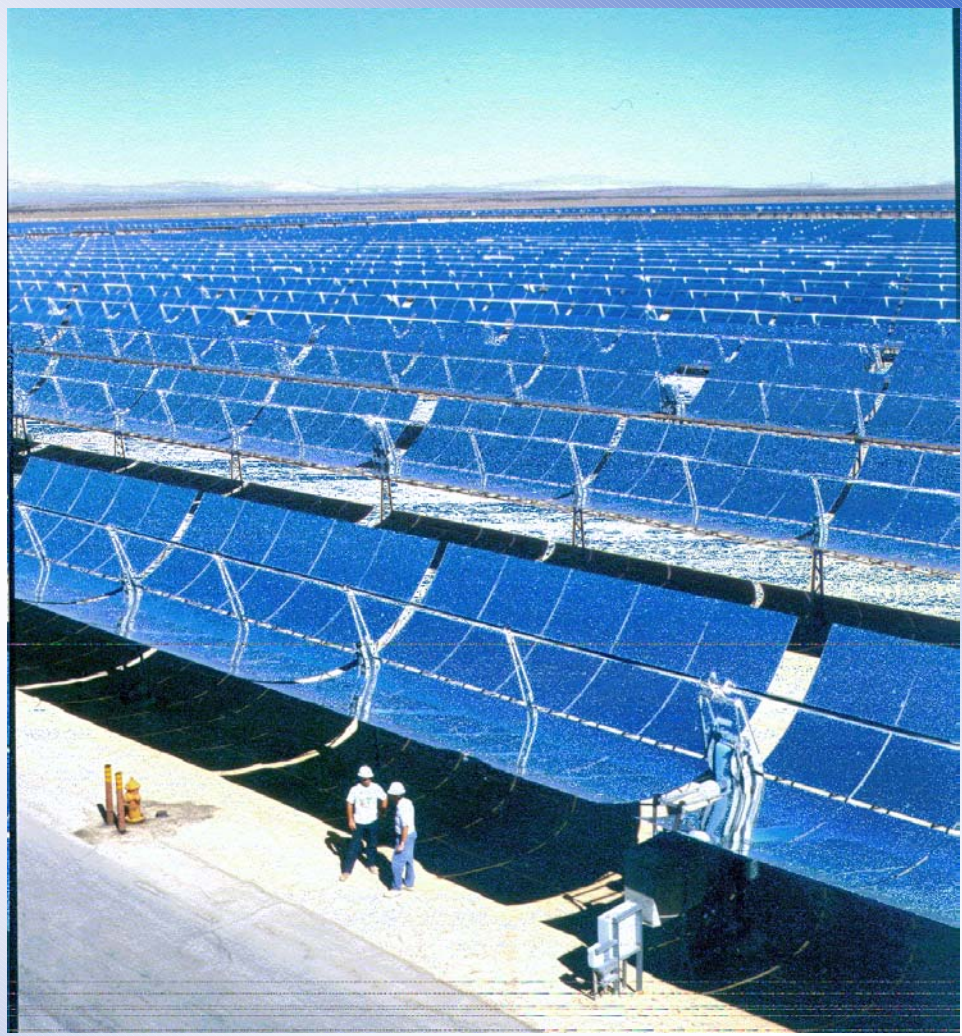
# CSP for Industrial Processes Heat

***A pilot project includes solar plant for Industrial Processes Heat and Energy Conservation System is located at El Nasr pharmaceutical chemicals company.***

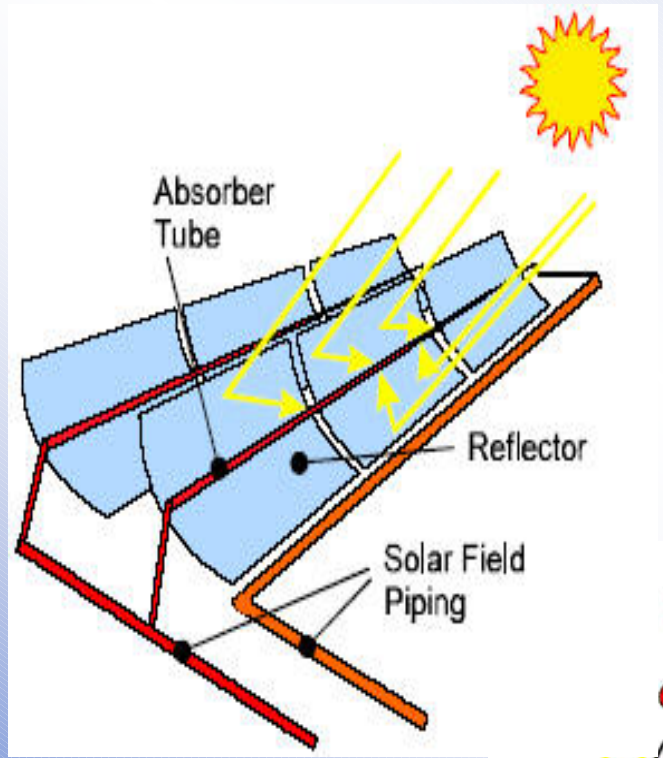
**The Solar Plant is to deliver 1.3 t/ h of saturated steam (at 175 °C / 8 bar), equivalent to 0.9 MWth to feed the steam network of the company, thereby reducing the fuel consumption.**

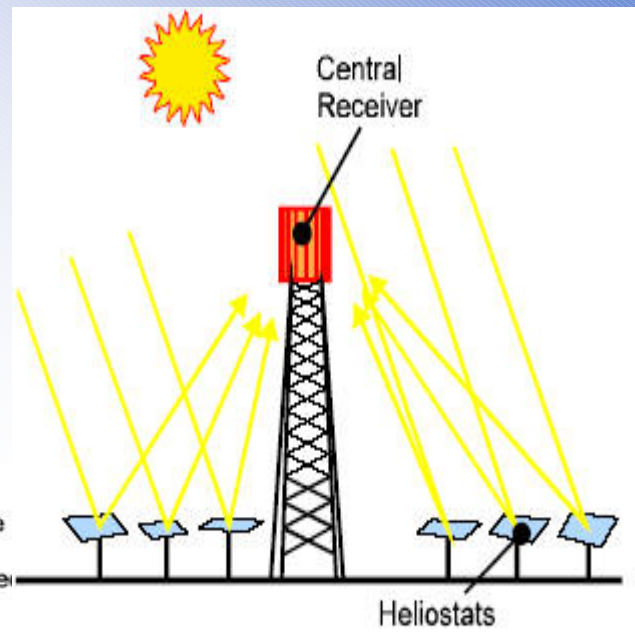
# Solar power plants exist!

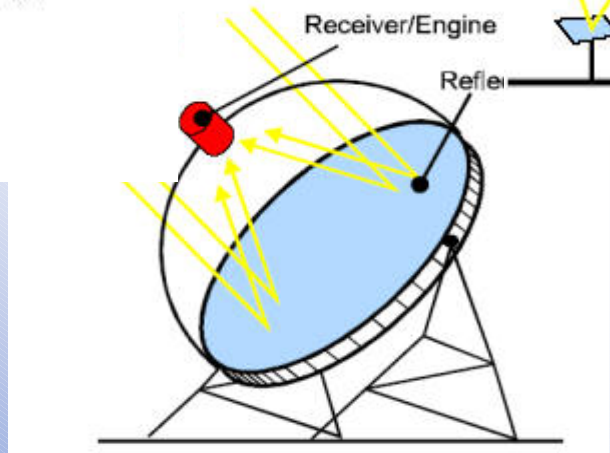
- 354 MWe since 84-89 on Los Angeles grid
- Concentrating solar power plants cheaper than PV
- Fossil fuel back-up or heat storage guarantees power
- 1 billion inhabitant in suitable areas
- Building work in Iran, Spain and the US
- Projects in a dozen other countries



# Three main concepts



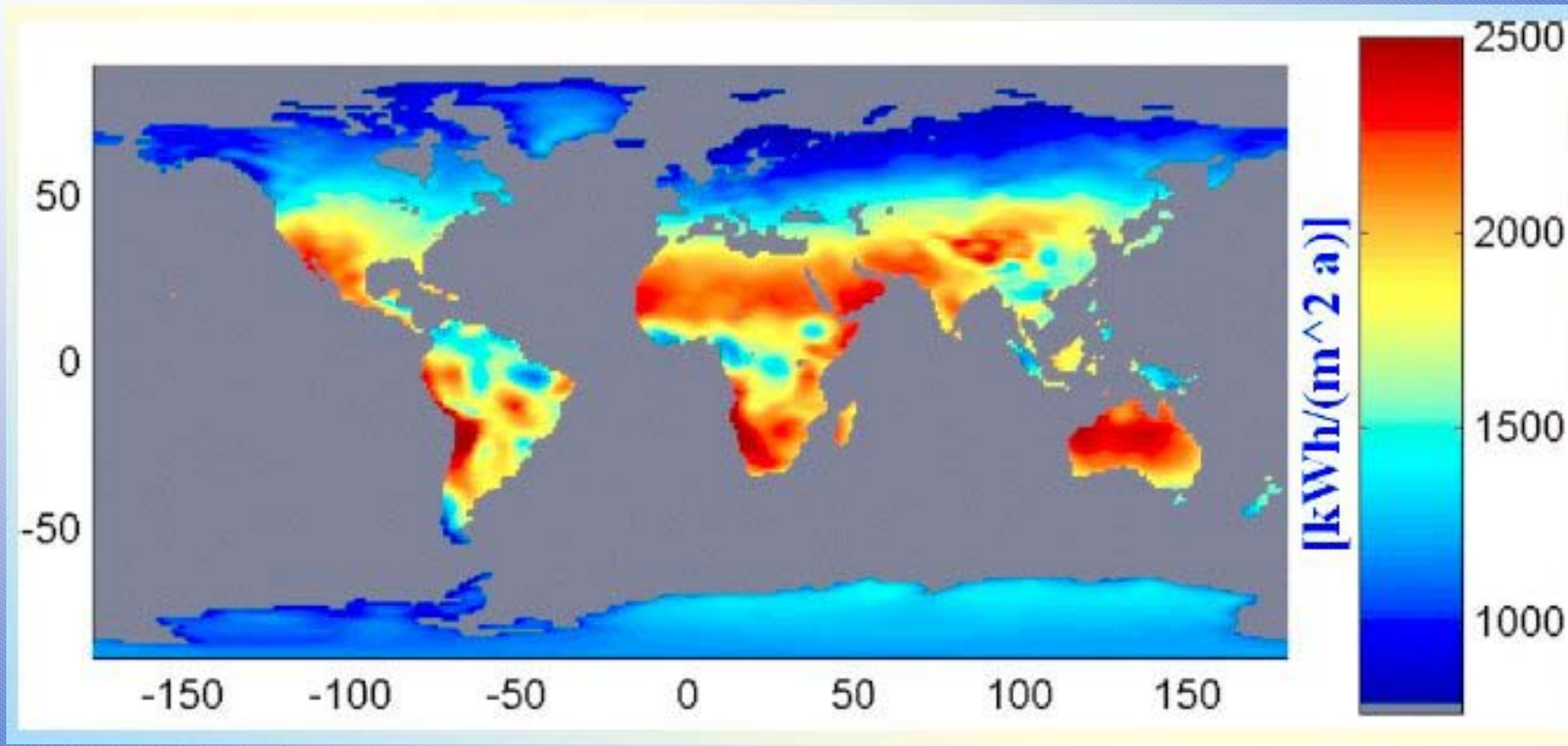



# From solar to power…

In the solar field, parabolic mirrors concentrate solar irradiation 80 times on an absorber tube.

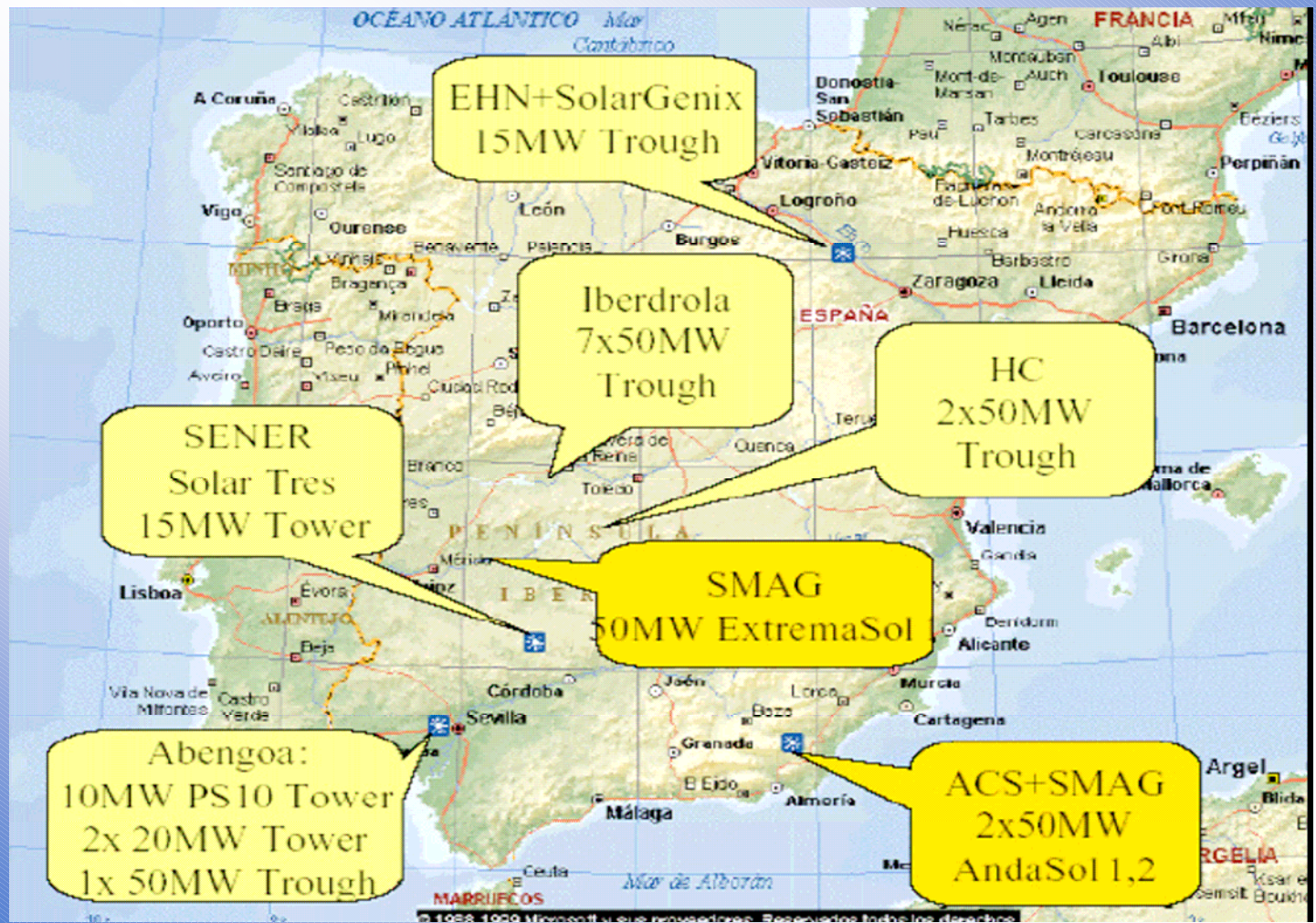
In a central power plant block, a heat exchanger then produces the steam, which powers the turbines.

# Resource is huge




**Concentrated in Countries with no Kyoto cap**

# Spain the new leader



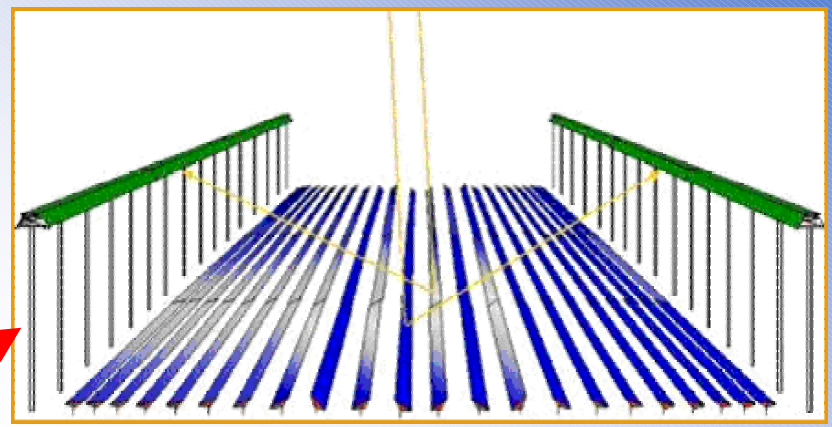
# Forthcoming 68-MWe plant Nevada

# The YAZD ISCC plant


**Construction started February 2006**

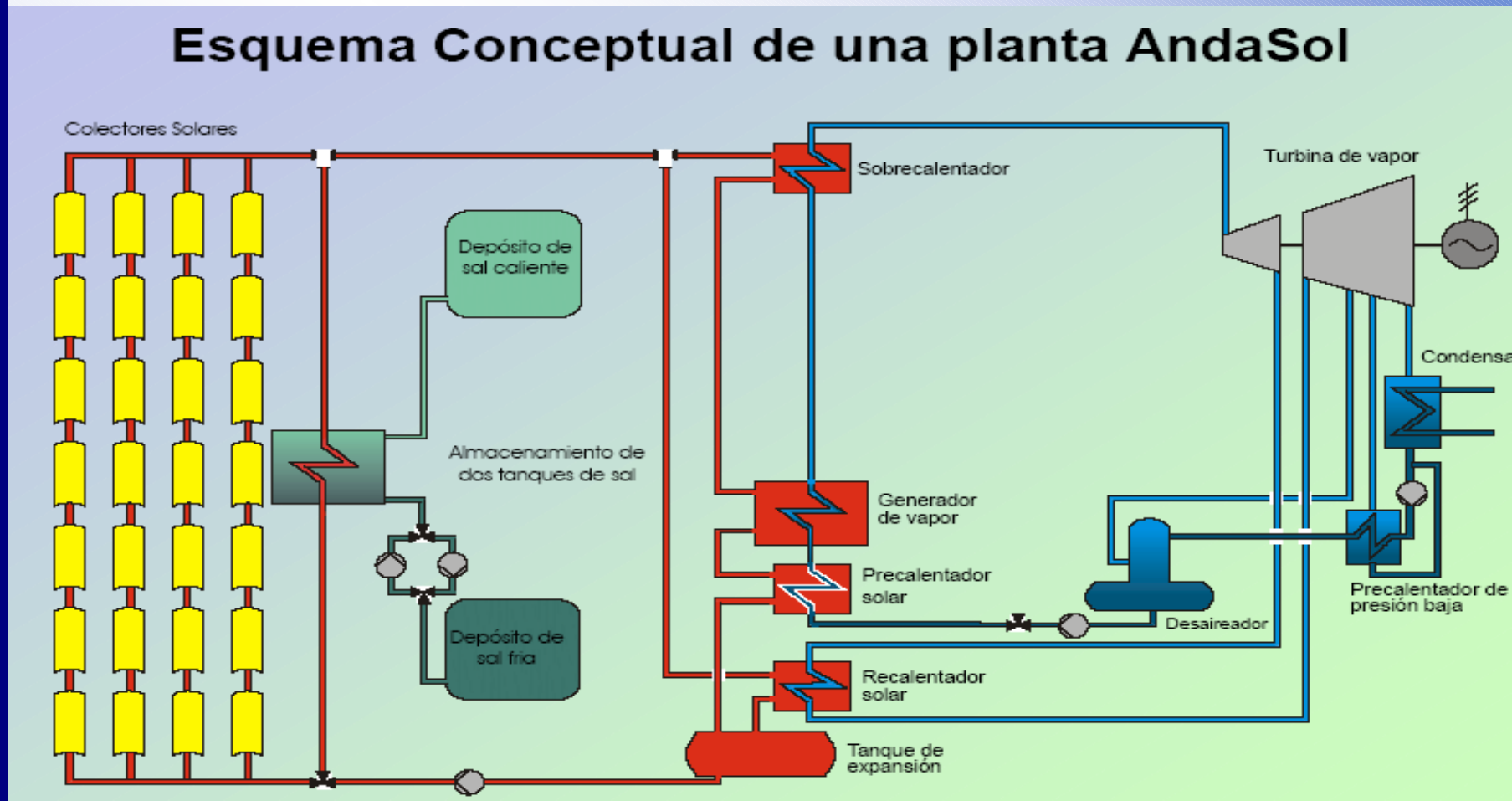
# New concepts

- Integrated Solar Combined Cycle power plants
- Direct Steam Generation
- Fresnel linear reflector
- Multi-towers arrays
- Molten salts for heat storage and continuous power production

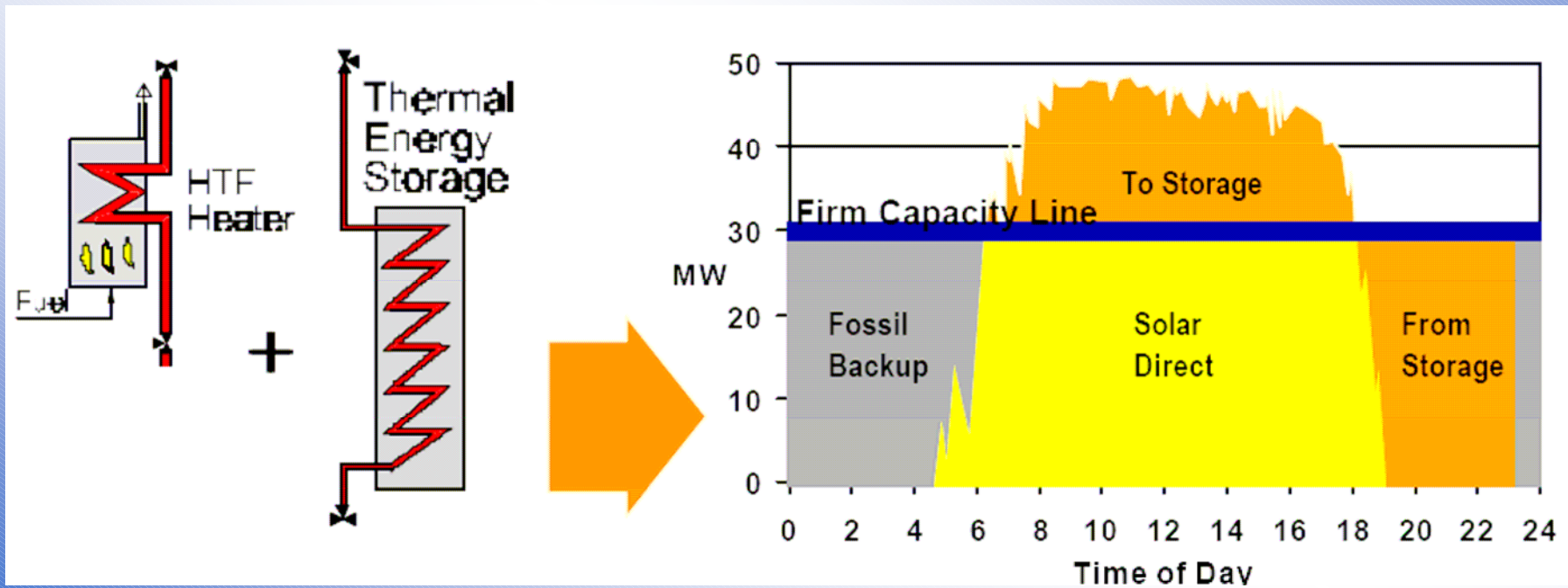


# Heat storage

*Delivering electricity on demand!*

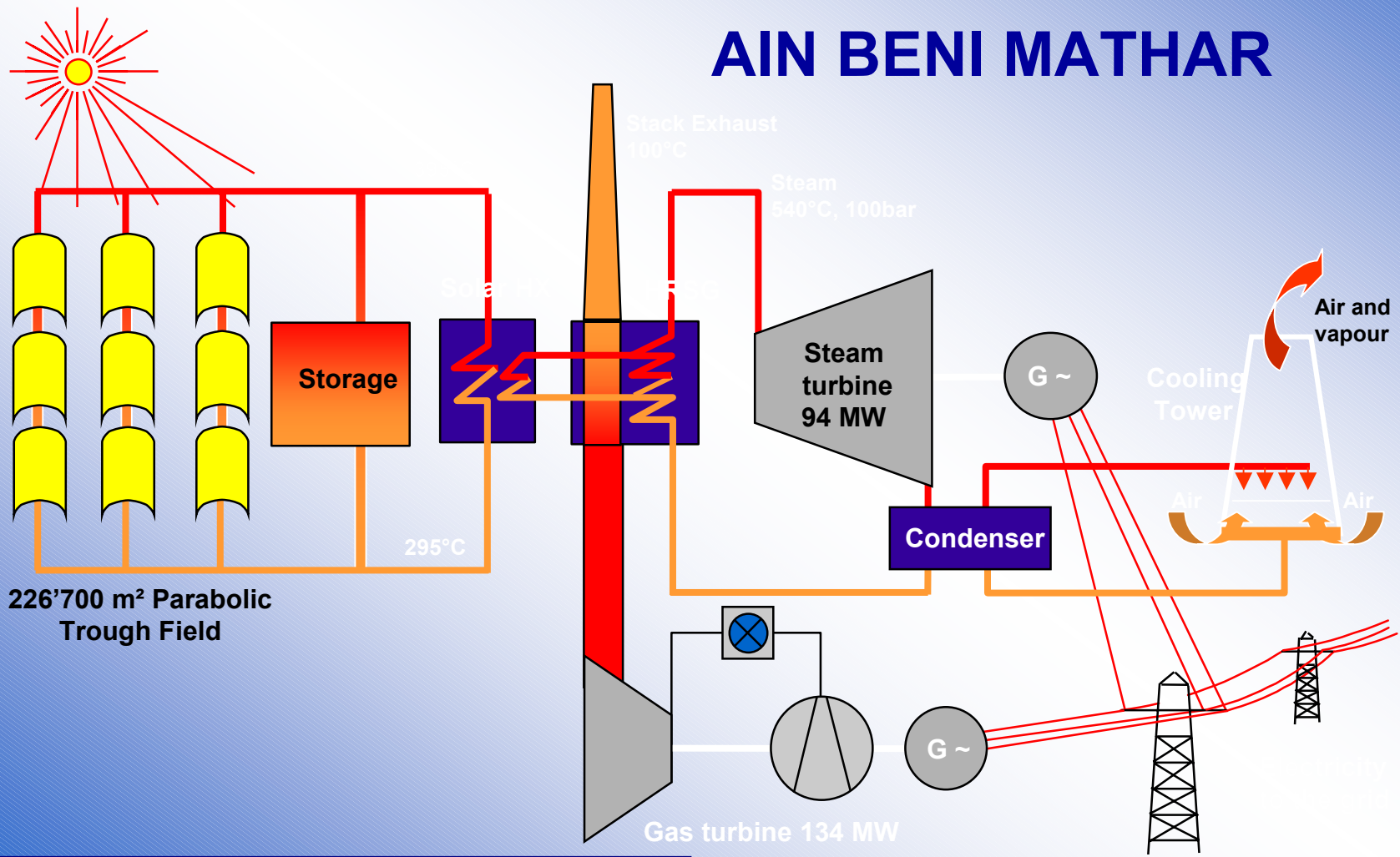


# Round-the-clock generation

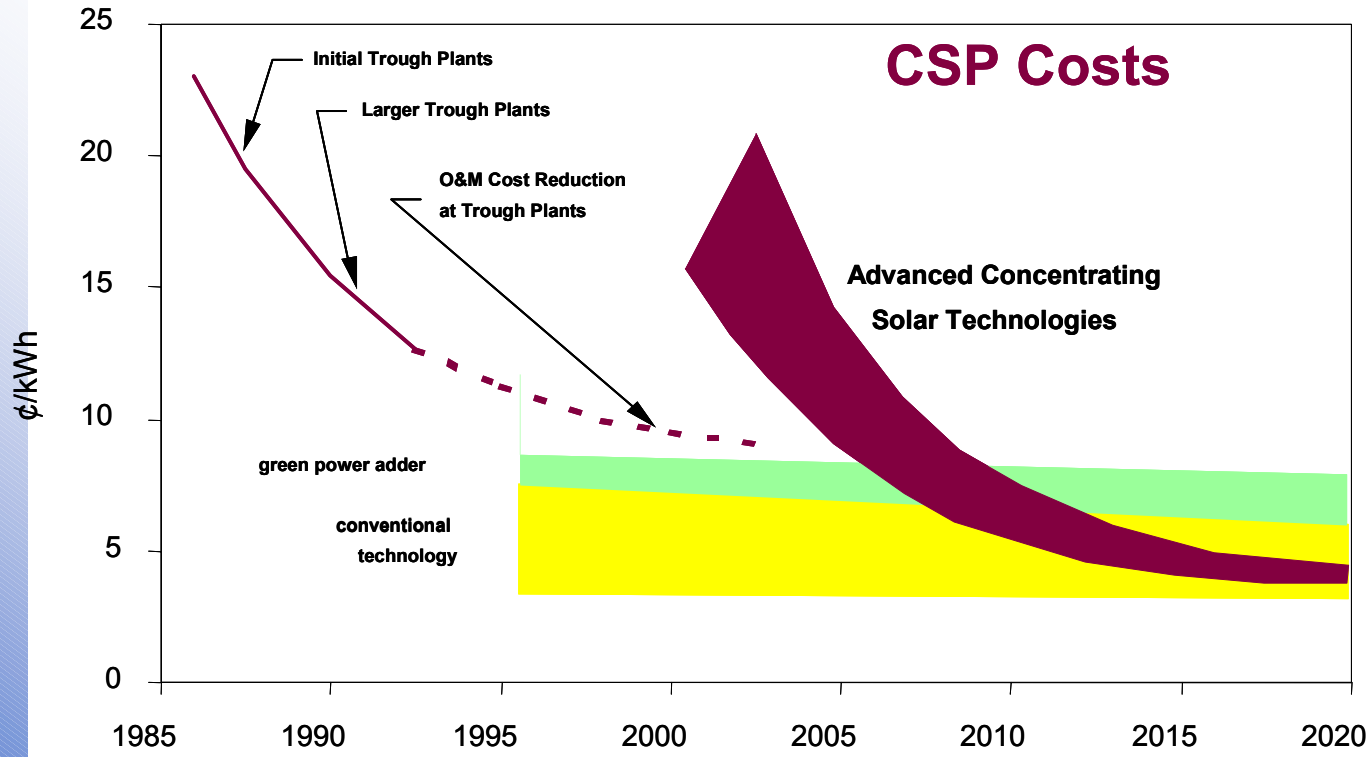


# Integrated Solar Combined Cycle

## AIN BENI MATHAR



# Learning curve…



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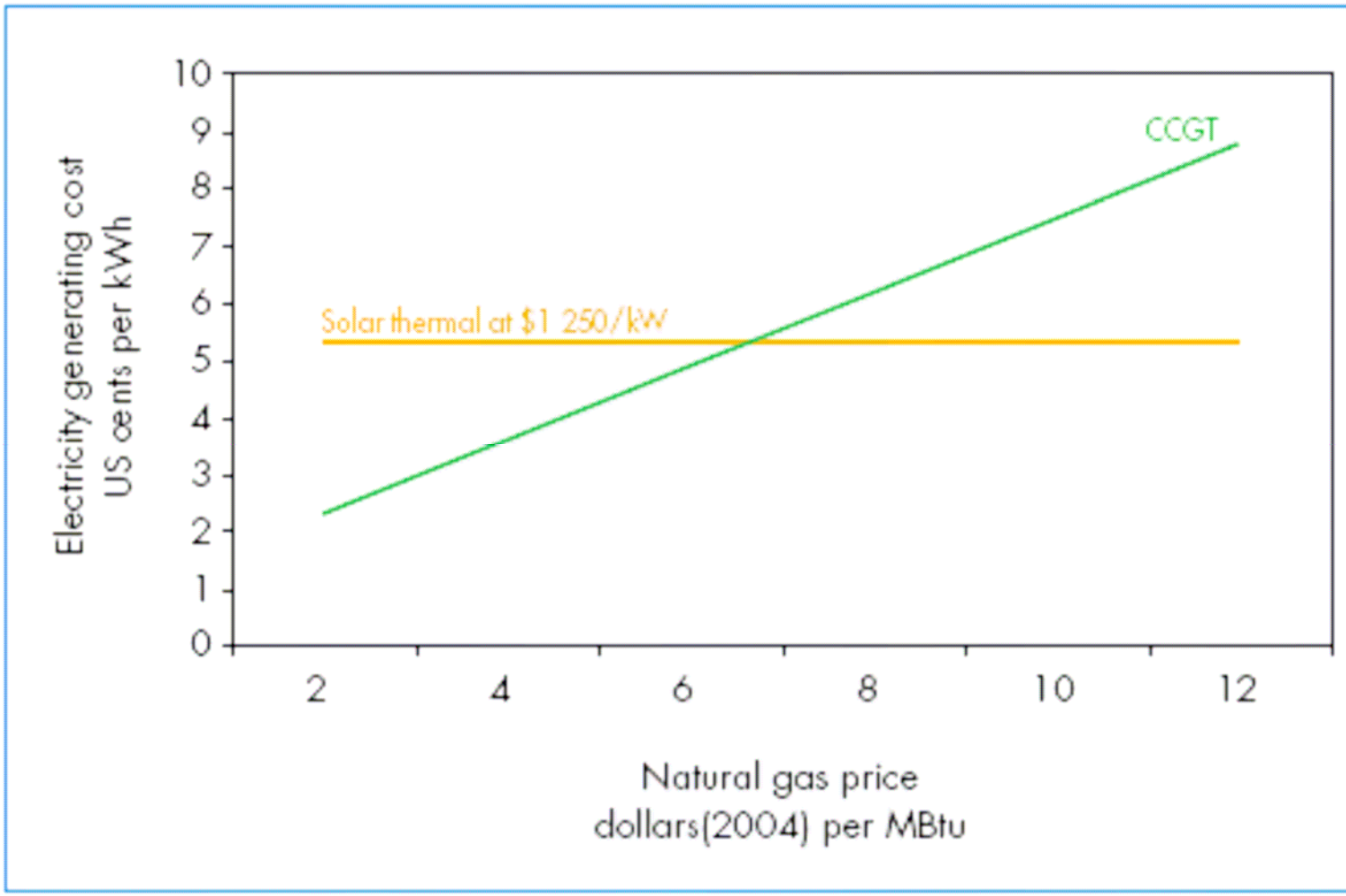
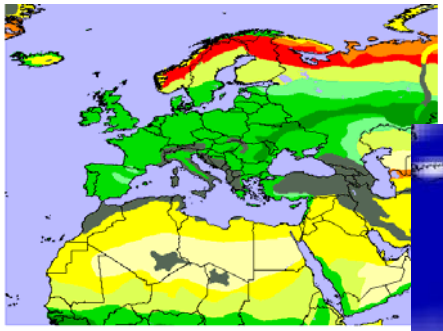
# Economic prospects

*Figure 6.17:* Solar Thermal and CCGT Electricity Generating Costs in 2030

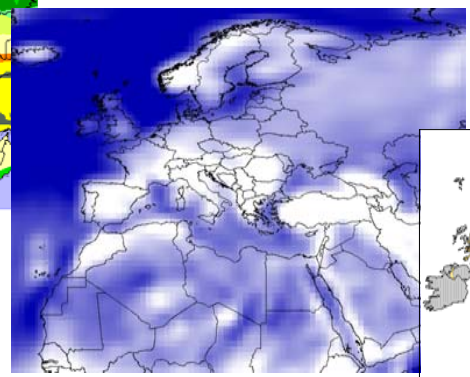


# Renewable Energy Resource Mapping: DLR's MED-CSP study

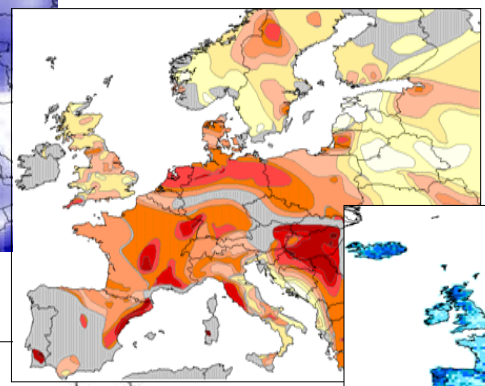
Biomass



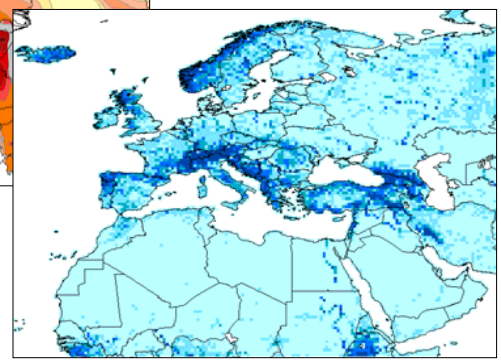
Wind Energy

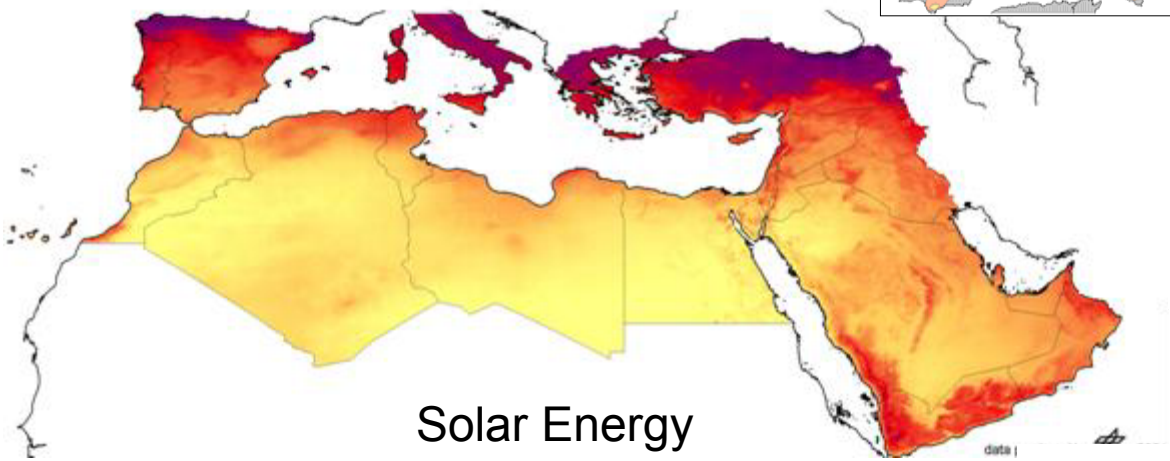


Geothermal Energy



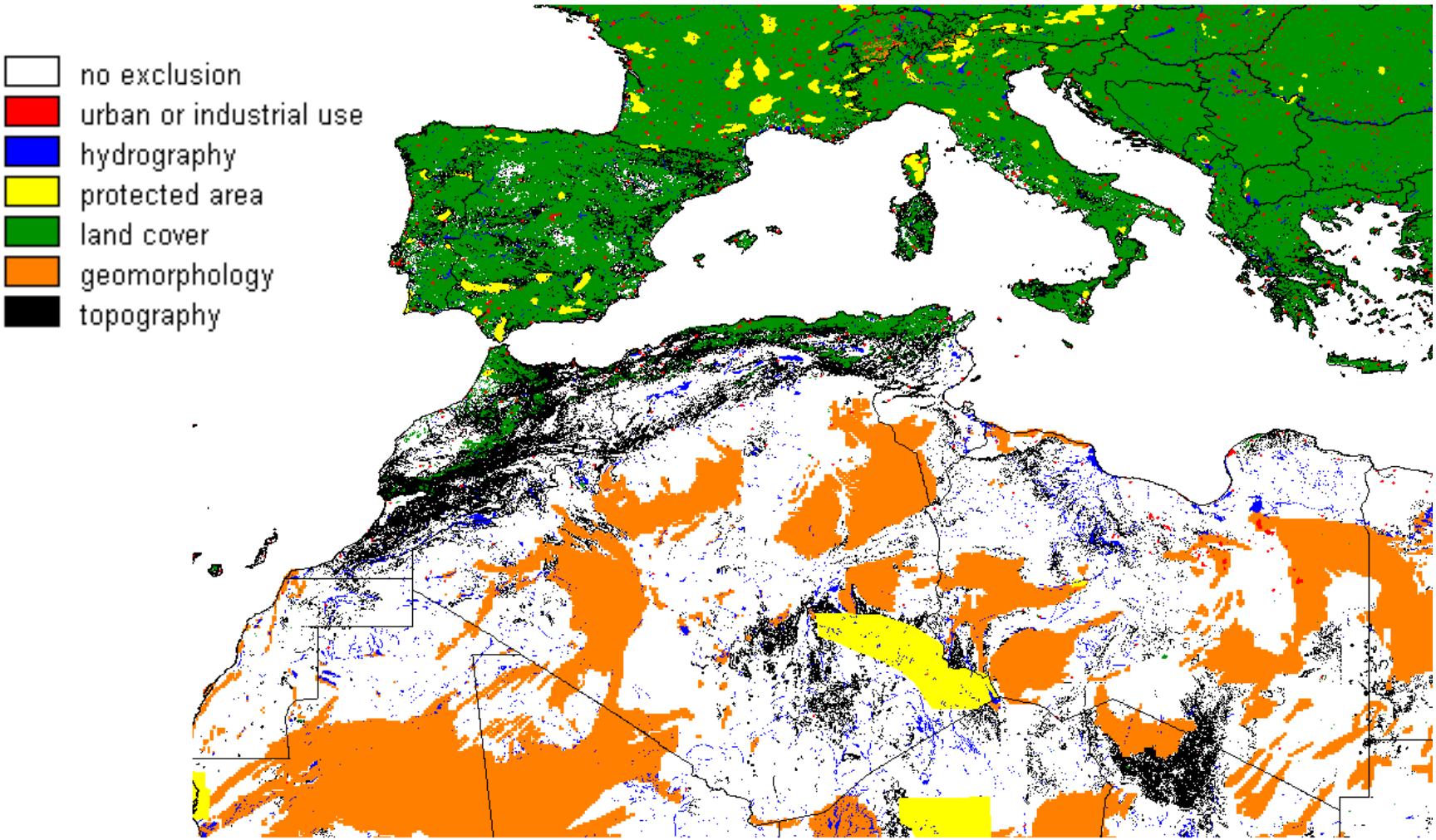
Hydropower





Solar Energy

# Exclusion Areas for Concentrating Solar Thermal Power Plants in Southern Europe and Maghreb Countries



# Potential by country (TWh/y)

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Cyprus | 20 | Algeria | 168972 | Iran | 20000 | Bahrain | |
| Greece | 4 | Egypt | 73656 | Iraq | 28647 | Kuwait | 15 |
| Italy | 7 | Lybia | 139477 | Israel | 318 | Oman | 194 |
| Malta | 2 | Morocco | 20146 | Lebanon | 14 | Qatar | 7 |
| Portugal | 142 | Tunisia | 9244 | Jordan | 6429 | UAE | 19 |
| Spain | 1278 | | | Syria | 10210 | Saudi Arabia | 1245 |
| | | | | Turkey | 131 | Yemen | 51 |
| Southern Europe | 1453 | Northern Africa | 411495 | Western Asia | 65749 | Arabian Peninsula | 1534 |

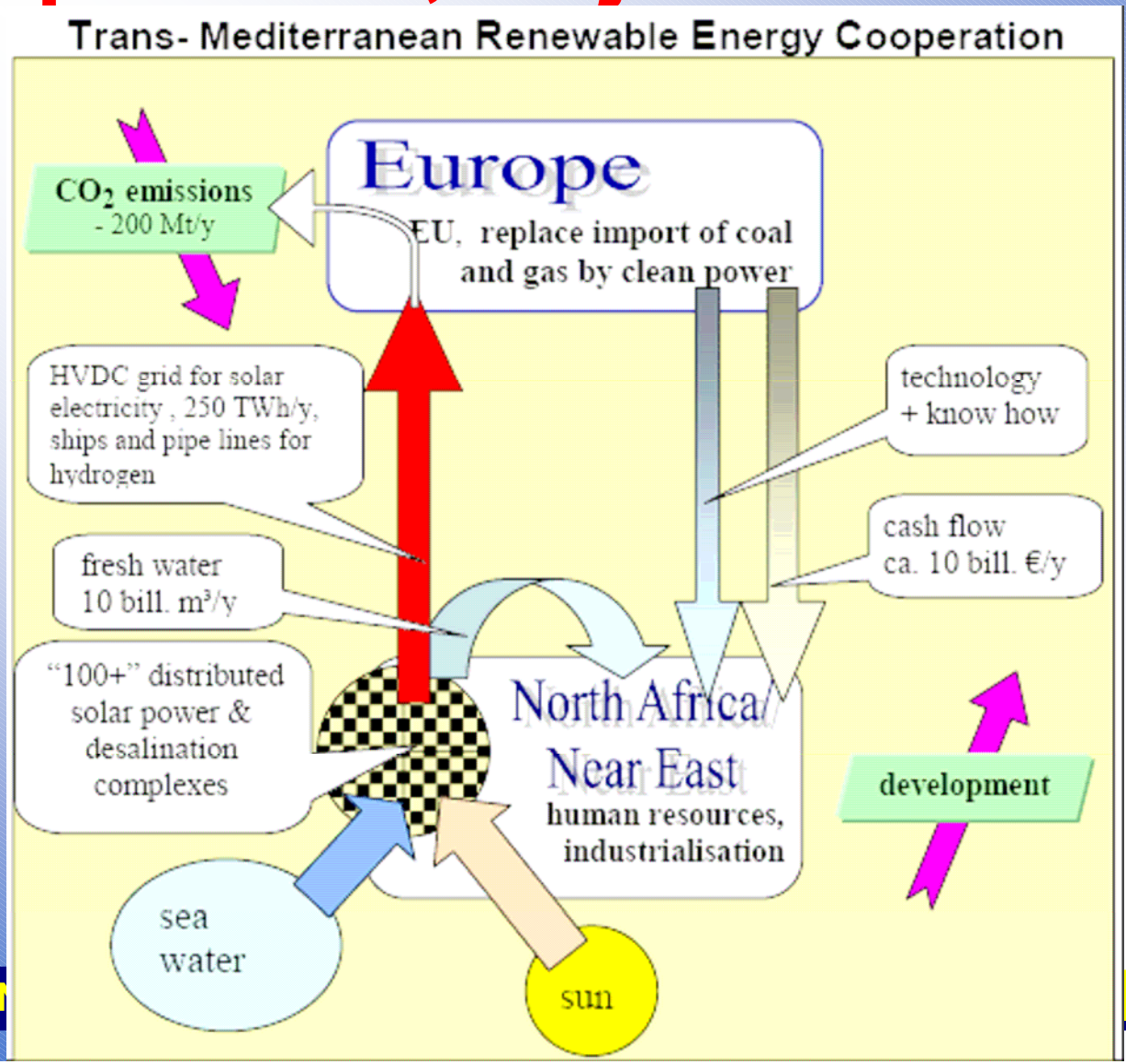
# Conclusions of the study

- In most MENA countries Concentrating Solar Power will provide the core of electricity in 2050
- Wind energy is a major resource in Morocco, Egypt and Oman,
- Geothermal power is available in Turkey, Iran, Saudi Arabia and Yemen.
- Major hydropower and biomass resources are limited to Egypt, Iran, Iraq and Turkey.

# Solar electricity exports?


**Modern HVDC lines would make them affordable**

# An example of North South cooperation, or just a dream?



# The IEA technology collaboration

- The 40 Implementing Agreements
- Voluntary participation by countries
- Open to developing countries & industry
- Fossil fuels, End use (transports, buildings, industry), nuclear fusion, cross-sectional activities (CTI, ETDE, ETSAP, EETIC), renewable and hydrogen:
- SolarPACES (CSP)
  - *Members:* Algeria, Australia, Brazil, Egypt, European Commission, France, Israel, Germany, Mexico, Spain, South Africa,Switzerland, and the US
- Solar Heating and cooling, PV-PS
- Bioenergy, Geothermal, Hydro Power, Wind Power, Ocean Energy Systems

# IEA SolarPACES test site