Investing in Desert Solar Technologies

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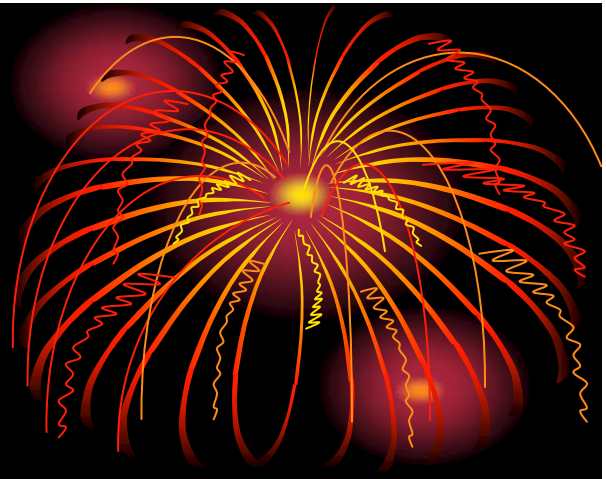
www.floatingsolarchimney.gr
www.matineeenergy.com



1. GLOBAL WARMING

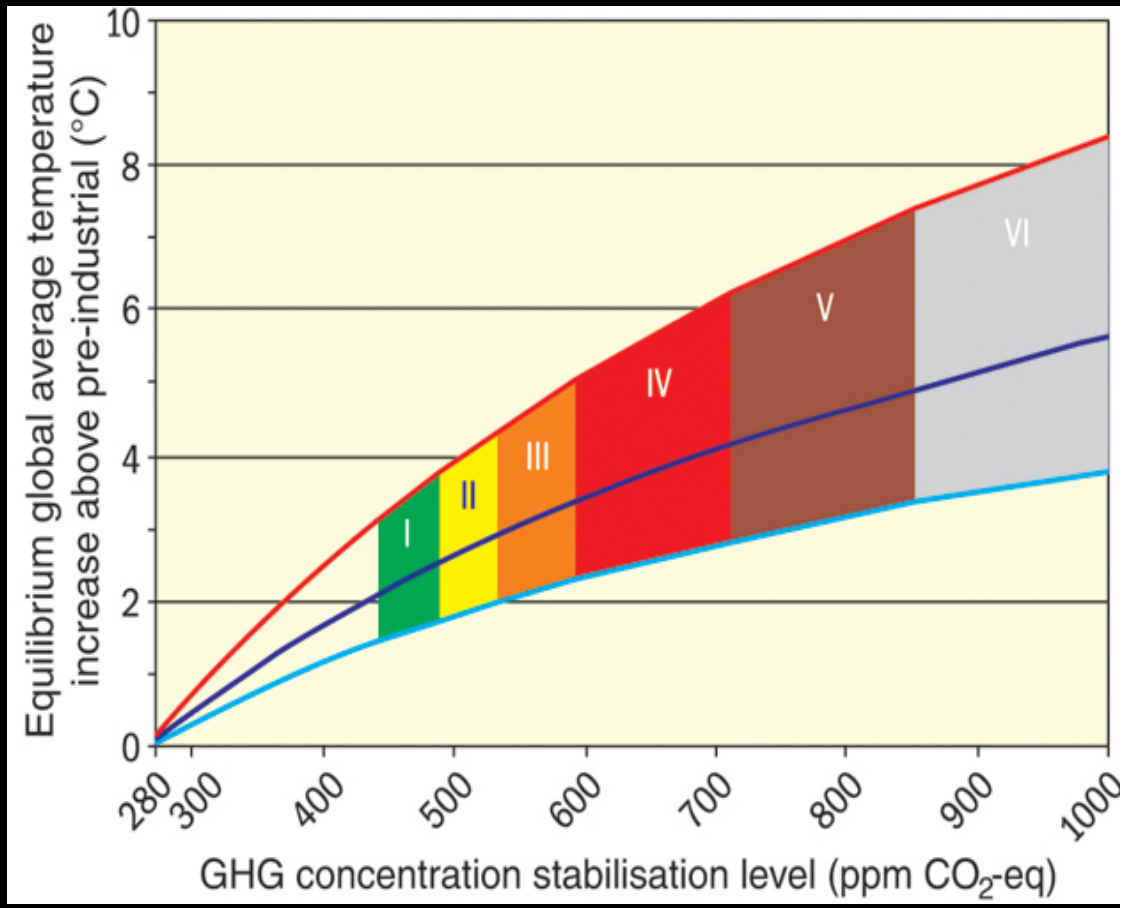
WE HAVE A SERIOUS PROBLEM

Global warming

- Global warming is a phenomenon observed and studied by many independent scientific institutions and is considered as a reality beyond any doubt
- Global warming is anthropogenic and it is the result of the greenhouse effect arising by the excess concentration of (CO_2) and other greenhouse gases (CH_4 etc) in the atmosphere, due to accelerating use of fossil fuels (coal, oil and natural gas) the last 100 years.
- For the official study of the global warming threat UN formed an international scientific committee (Intergovernmental Panel on Climate Change or IPCC).

The earth temperature change due to global warming by CO2 emissions

- Even with the best IPCC scenario the global temperature increase until the end of the century will be (1.8÷3.2 0C)
- Without any measures this increase could be higher than 8 0C
- The increased global temperature will last for hundreds of years

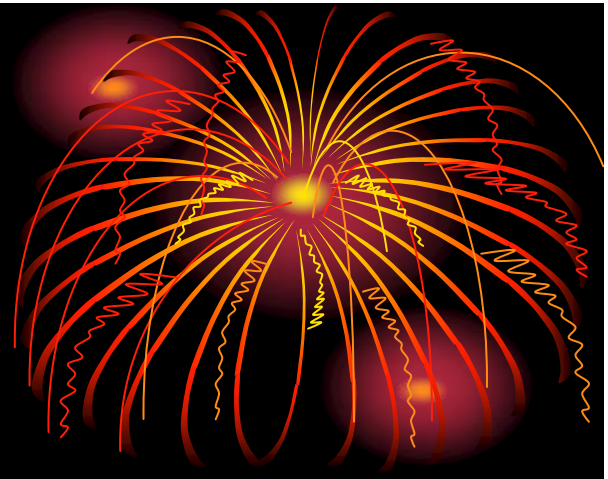


The global warming effects

- Athropogenic warming and sea level rise would continue for centuries even if greenhouse gas concentrations were to be stabilized
- Eventual melting of the Greenland (and maybe of the Antarctic) ice sheet, would raise sea level by 7 m
- This will be evident even before 2050

Precipitation change & extreme catastrophic events

- Due to precipitation changes fertile land devastation is possible in many areas
- The existing atmospheric models can not exclude the appearance of the most catastrophic extreme events (very strong typhoons, tornados, snow or hail storms)



2. Solar Desert Electricity technologies with uninterrupted power supply

Photovoltaics with Batteries

- **Photovoltaic Systems transform straightforward the solar irradiation to DC electricity and using appropriate inverters to grid AC**
- **The PVs are generating interrupted electricity however they should be equipped with a massive storage energy system, usually it is a set of batteries, for its uninterrupted power supply**
- **The main disadvantage of the PV technology is its high investment cost (That cost is more than 3miilion EURO per produced GWh/year)**
- **Thus the direct cost per produced KWh would be not less than 0.28 EURO (20 year operation of the plant, loan with interest rate 6.5% + OM~0.01-0.15 EURO/KWh)**

View of a Photo-Voltaic solar Park

Concentrating Solar Power Plants (CSP)

- **The CSP systems**

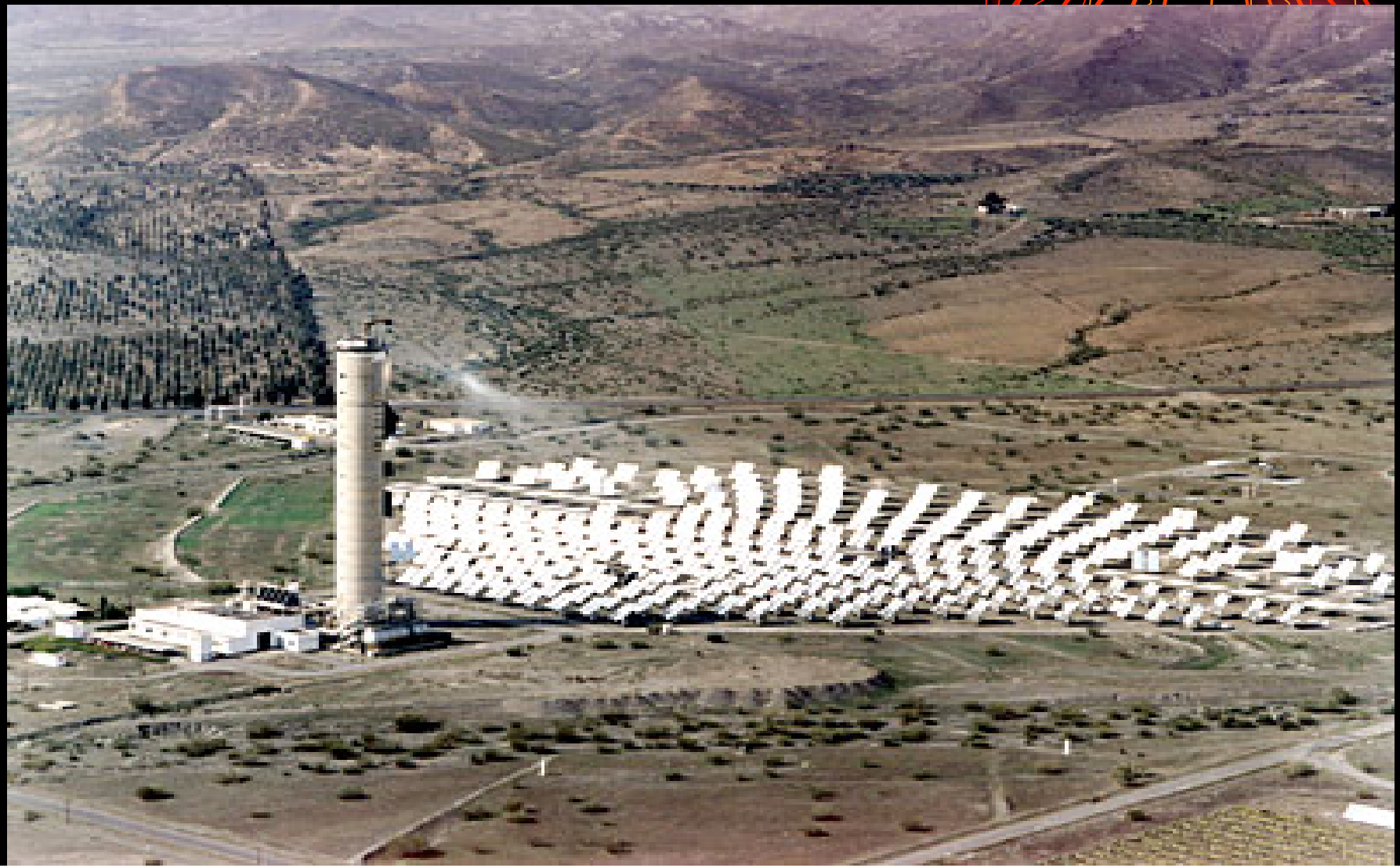
  Using appropriate mirrors they concentrate the solar energy in order to increase the temperature of a circulating fluid above 300 oC. The circulating fluid transfers its thermal energy to steam used, in proper combined cycle power plants(steam turbines engaged to electric generators), generating electricity

- **For uninterrupted power generation the CSP should be supported by a Thermal Energy Storage (TES) system and maybe they should burn some NGas**

The main CSP systems are:

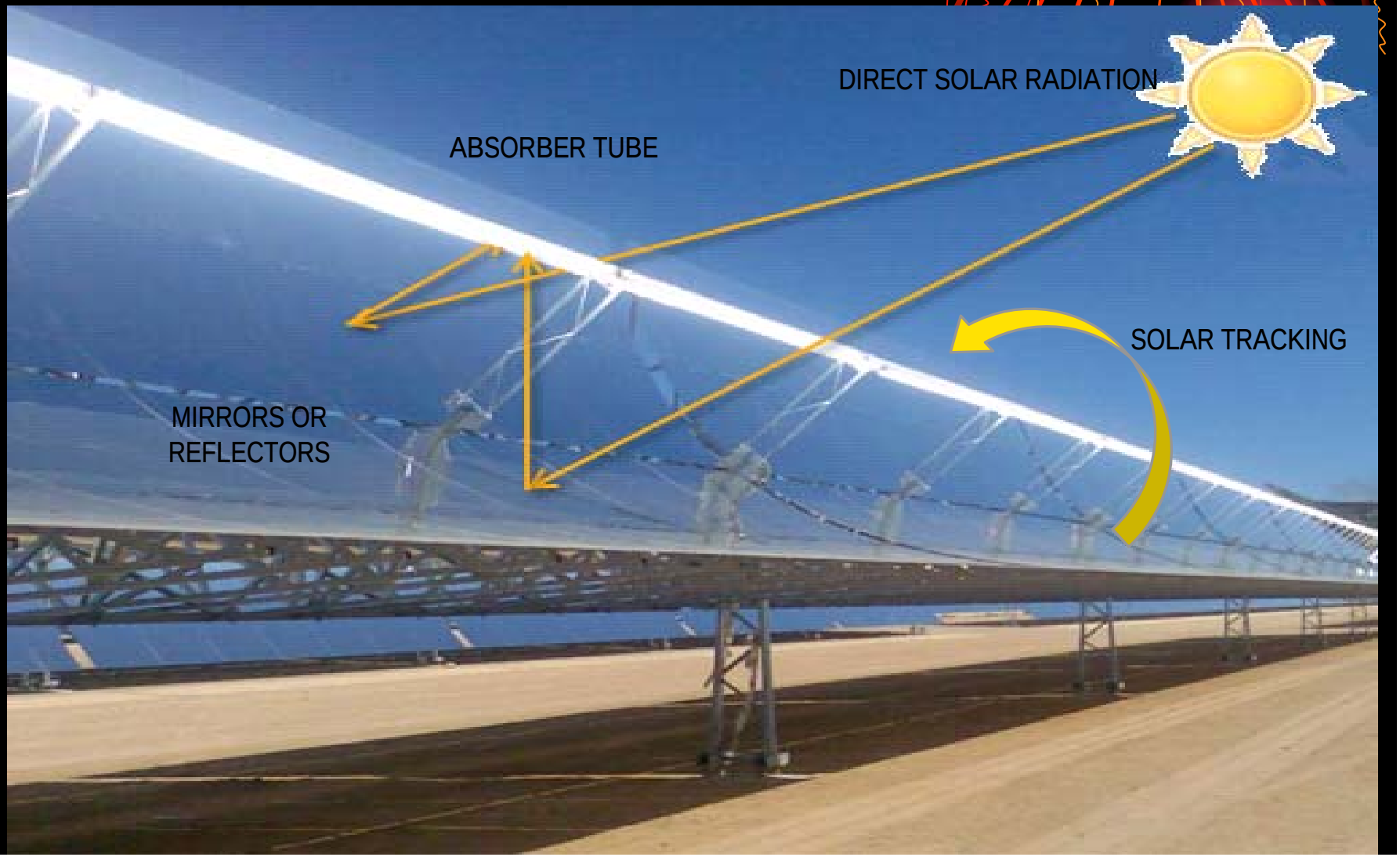
- **Solar Towers**
- **Solar dishes**
- **Parabolic through (Most preferred)**

SOLAR TOWER

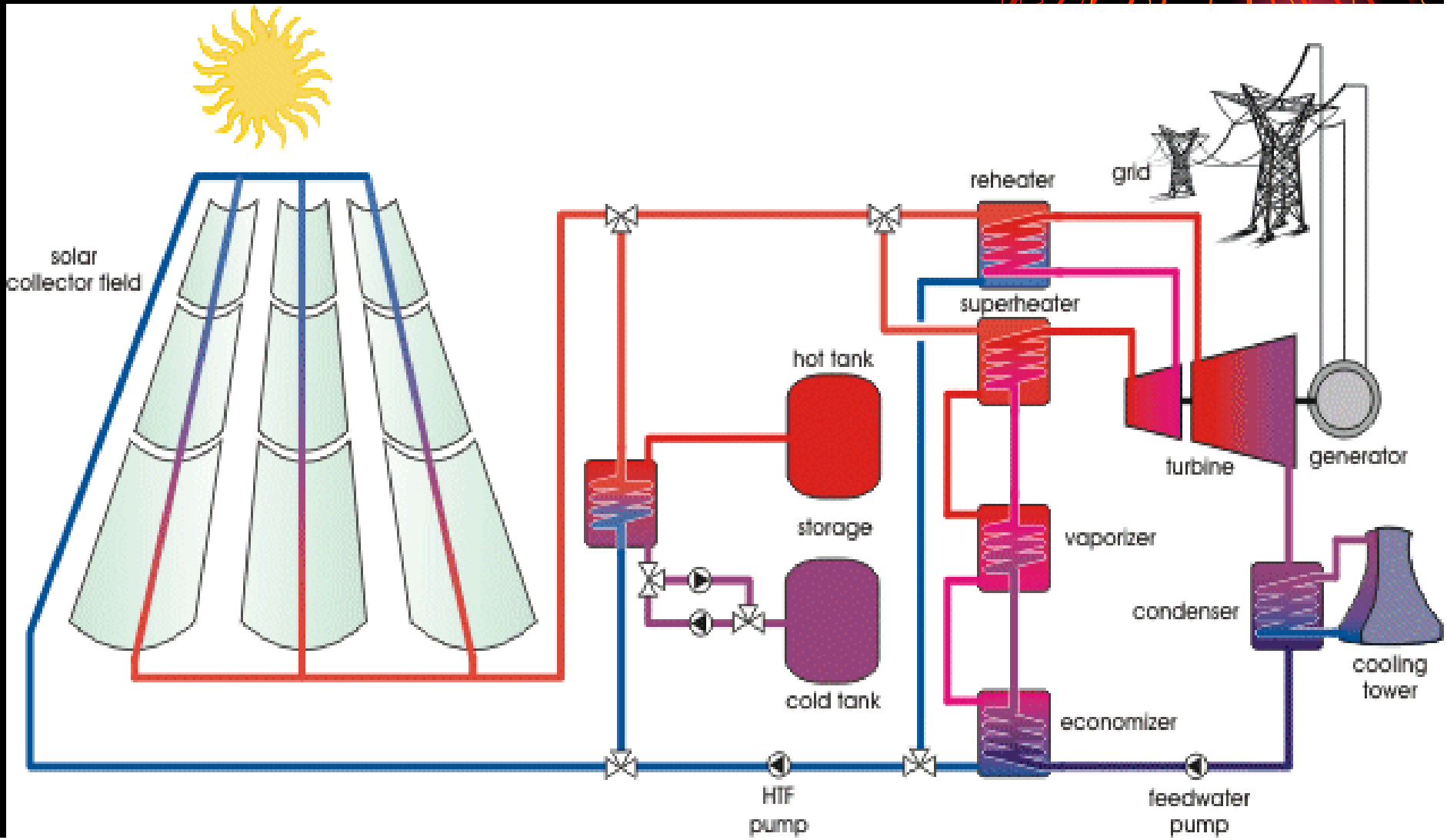


SOLAR DISH

Indicative operation of Parabolic Through



Parabolic Through with Thermal Storage (TES)



Parabolic Through System

- Parabolic through investment cost is lower than PV investment cost per produced KWh/year (> 2 million EURO per produced GWh/year)
- Thus the direct cost per produced KWh would be not less than 0.18 EURO (25 year operation of the plant, loan with interest rate 6.5% + OM~0.01-0.15 EURO/KWh)
- A disadvantage of the CSP systems is that they need water for their steam plants and the cooling and cleaning of their mirrors

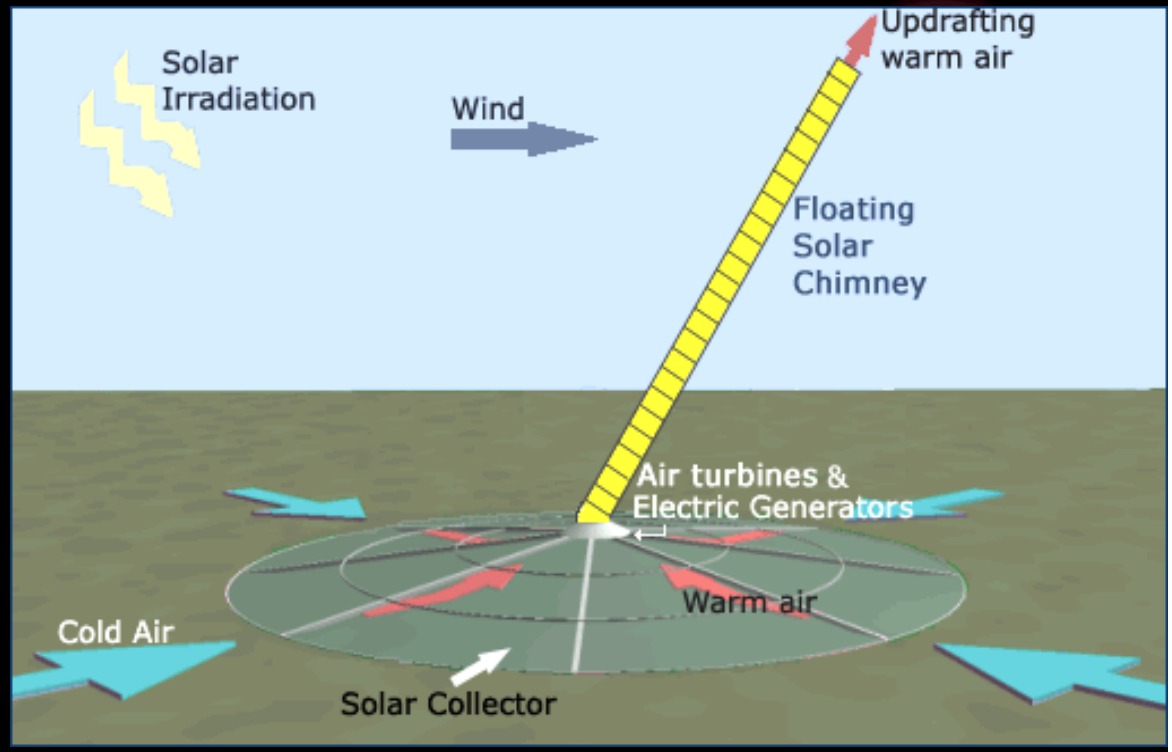
Solar Chimney Technology

- They use open greenhouses in order to warm the ground and the air below their transparent roofs
- The warm air tends to escape through tall chimneys near the center of the greenhouses
- This stream of lighter than ambient warm air rotates a set of air turbines near the bottom of the solar chimney
- The rotating air turbines are engaged through proper gearboxes with electric generators supplying electricity to the grid through electric transformers
- The solar chimney technology to the ground thermal storage below the greenhouse has a natural thermal storage system
- Thus solar chimney technology power plants are operating continuously 24h/day 365 days/year. For smoother power profile the greenhouse can be supported by artificial thermal storage means (closed tubes filled with water)
- The solar chimneys can be made with reinforced concrete (very expensive structures)
- Or inexpensive lighter than air structures made of light fabric and raised by the buoyancy of special balloons attached to them (Floating Solar Chimneys)

Floating Solar Chimney technology Power plant

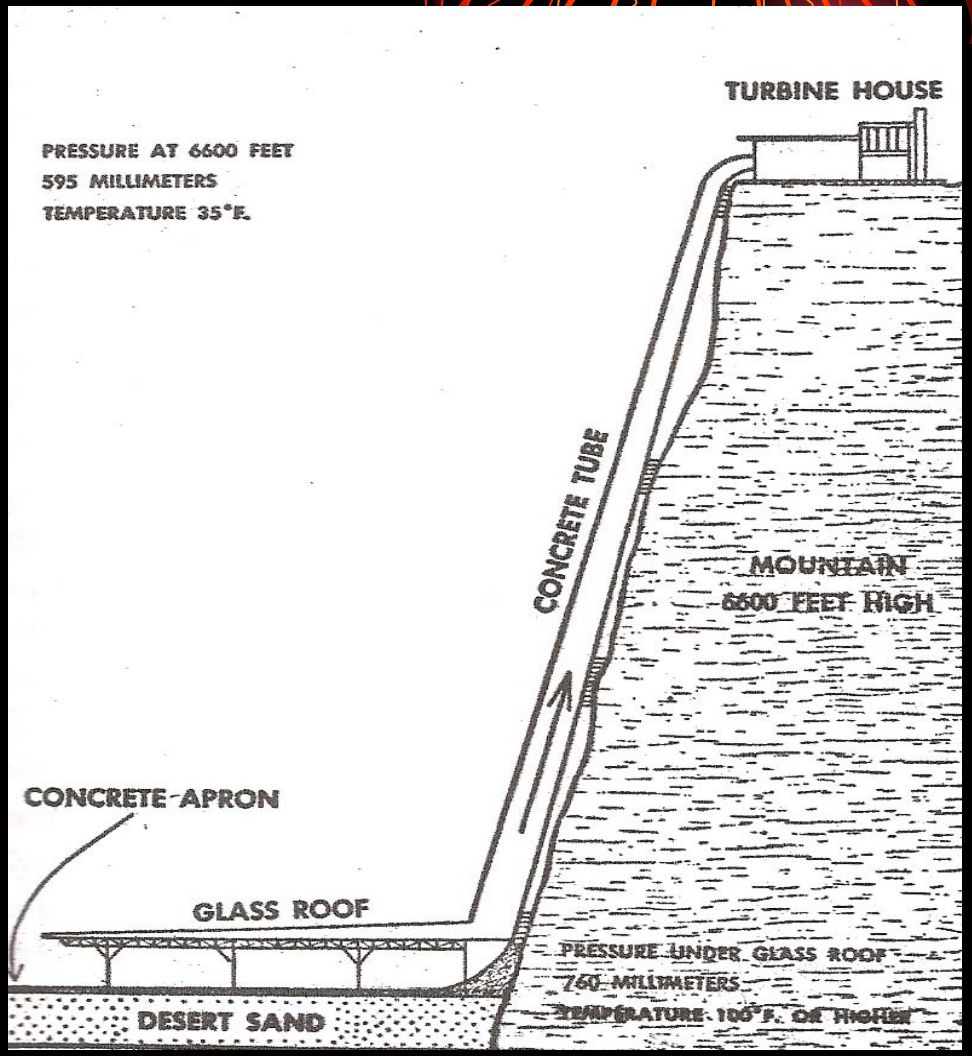
A Solar Chimney PP is made of three components:

- A large solar collector with a transparent roof supported a few meters above the ground (The Greenhouse)
- A tall, warm air up drafting, Cylinder on the center of this Greenhouse (The Floating Solar Chimney)
- A set of Air Turbines geared to appropriate Electric Generators around the base of the Solar Chimney (The Turbo Generators).



History (1)

- In 1926 Prof Engineer Bernard Dubos proposed to the French Academy of Sciences the construction of a Solar Aero-Electric Power Plant in North Africa with its solar chimney on the slope of the high height mountain



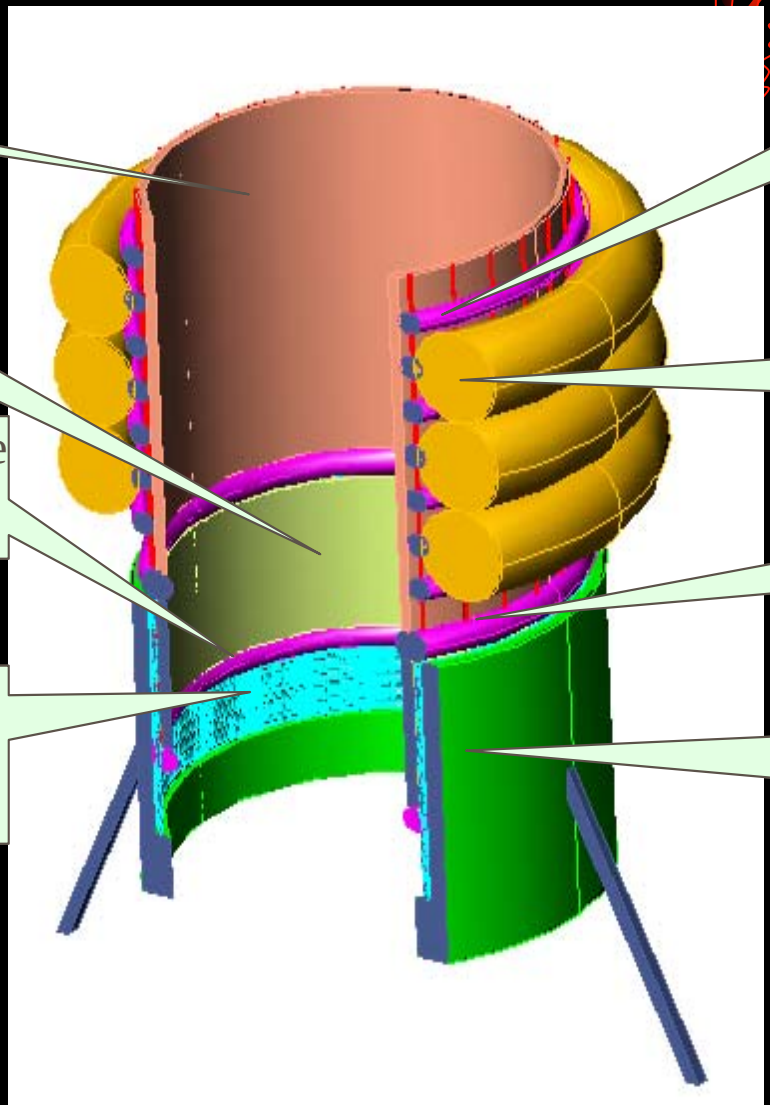
History (2)

- Prof Dubos proposal was soon abandoned as very costly
- Later in 1980 with the financing of German government,
- Prof Engineer J. Schlaigh built a small prototype of a solar Aero-Electric power plant of 50 KW in Manzanares of Spain
- The solar chimney was 196 m high, with internal diameter 10 m
- The greenhouse area was 45.000 sqm
- The prototype was operating successfully for 8 years

History (3)

- Prof J.Schlaigh proposed to build Solar Aero-Electric power plants with reinforced concrete solar chimneys of heights (500m-1000m)
- In 2002 this simple solar technology has attracted my attention, however I realized that the tall concrete structures (beyond the problems of earthquakes) will be of high cost, that can limit large scale application of this technology .
- In 2009 I received the EU patent for my invention of a low cost alternative. A lighter than air fabric structure, free standing and inclining by the external winds.
- Due to its patented construction this Floating (in the air) Solar Chimney can encounter external winds and operating sub pressures, executing its operational duties very effectively

A small part of the Floating Solar Chimney



Inner fabric wall

Strong fabric of the heavy base

Lower ring of the heavy base

Accordion type folding lower part

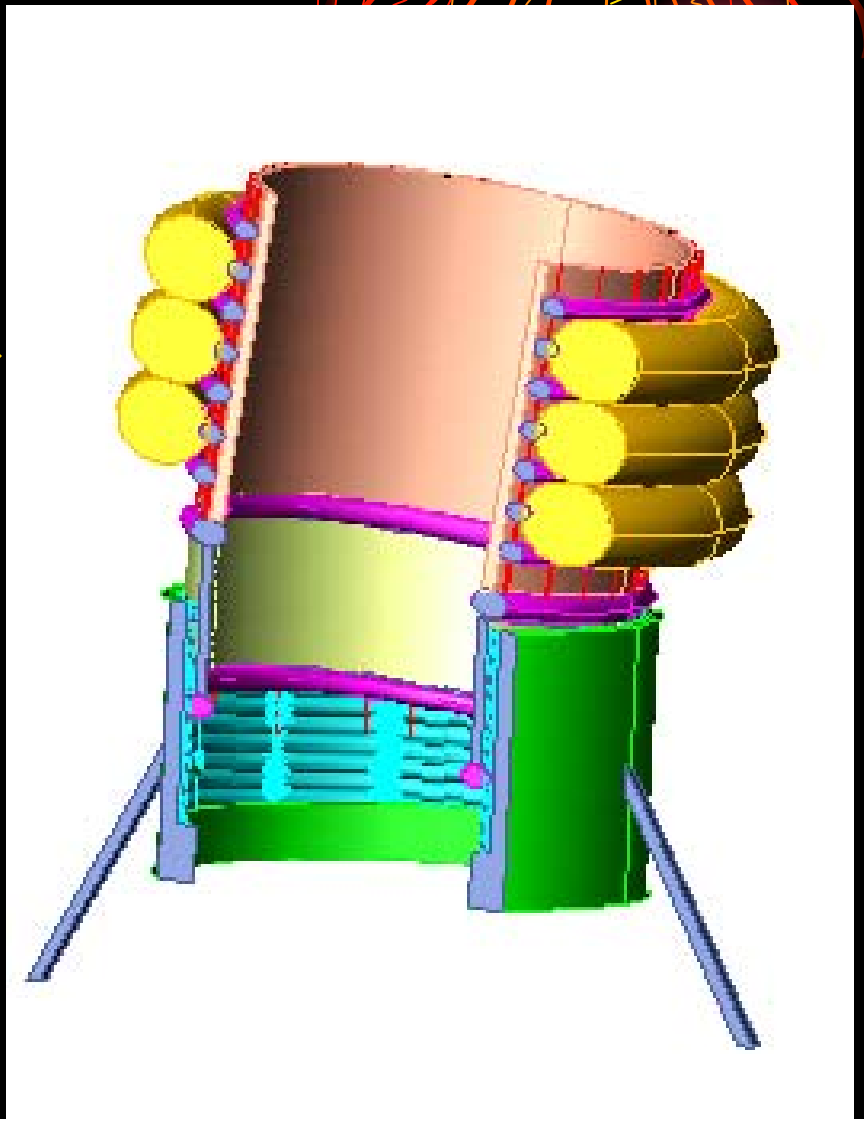
Supporting Ring Inflated or Aluminum tube

Lifting Tube Filled with lifting Gas

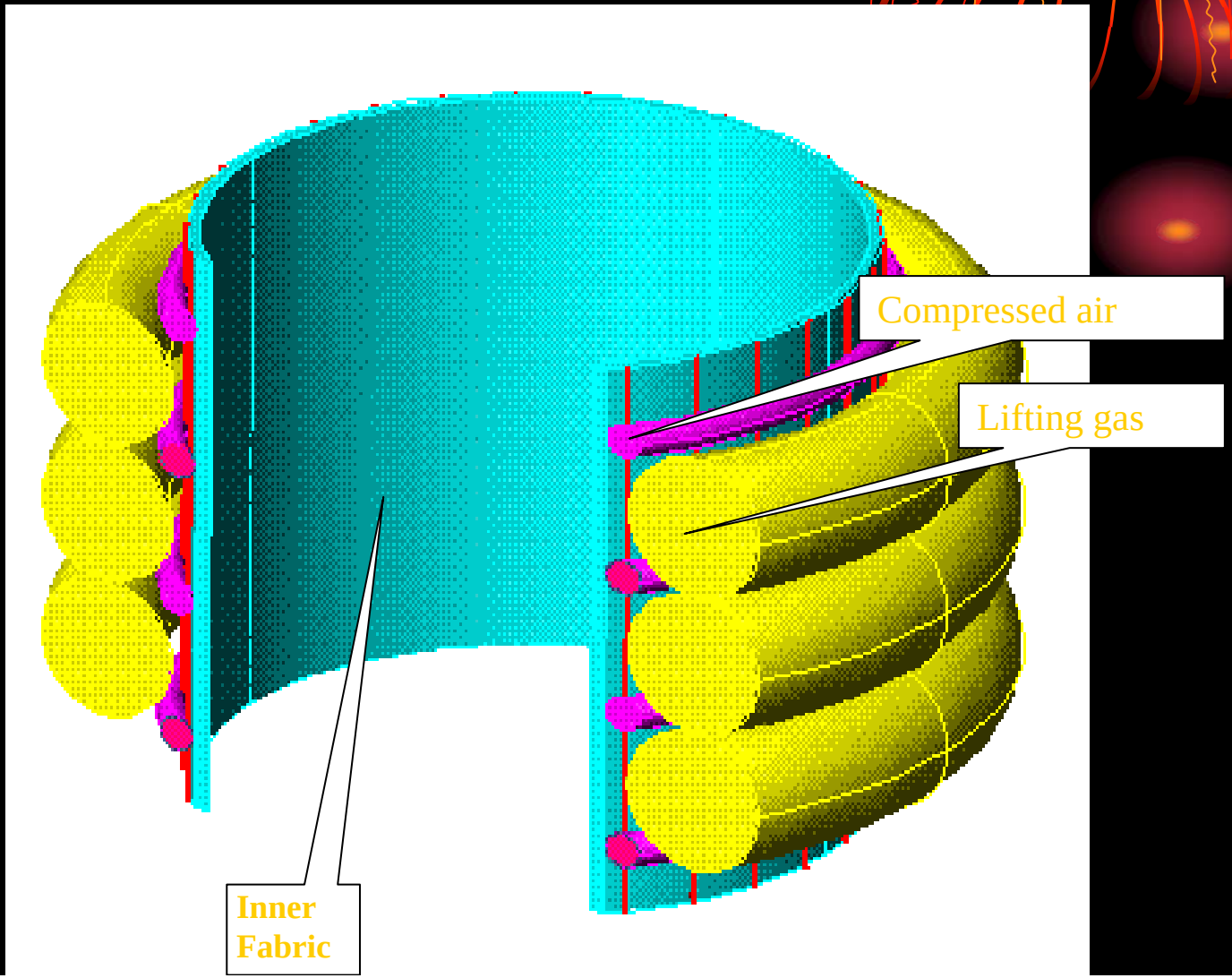
Upper Ring of the heavy base

Seat of the floating solar chimney

Floating Solar Chimney inclining under external winds

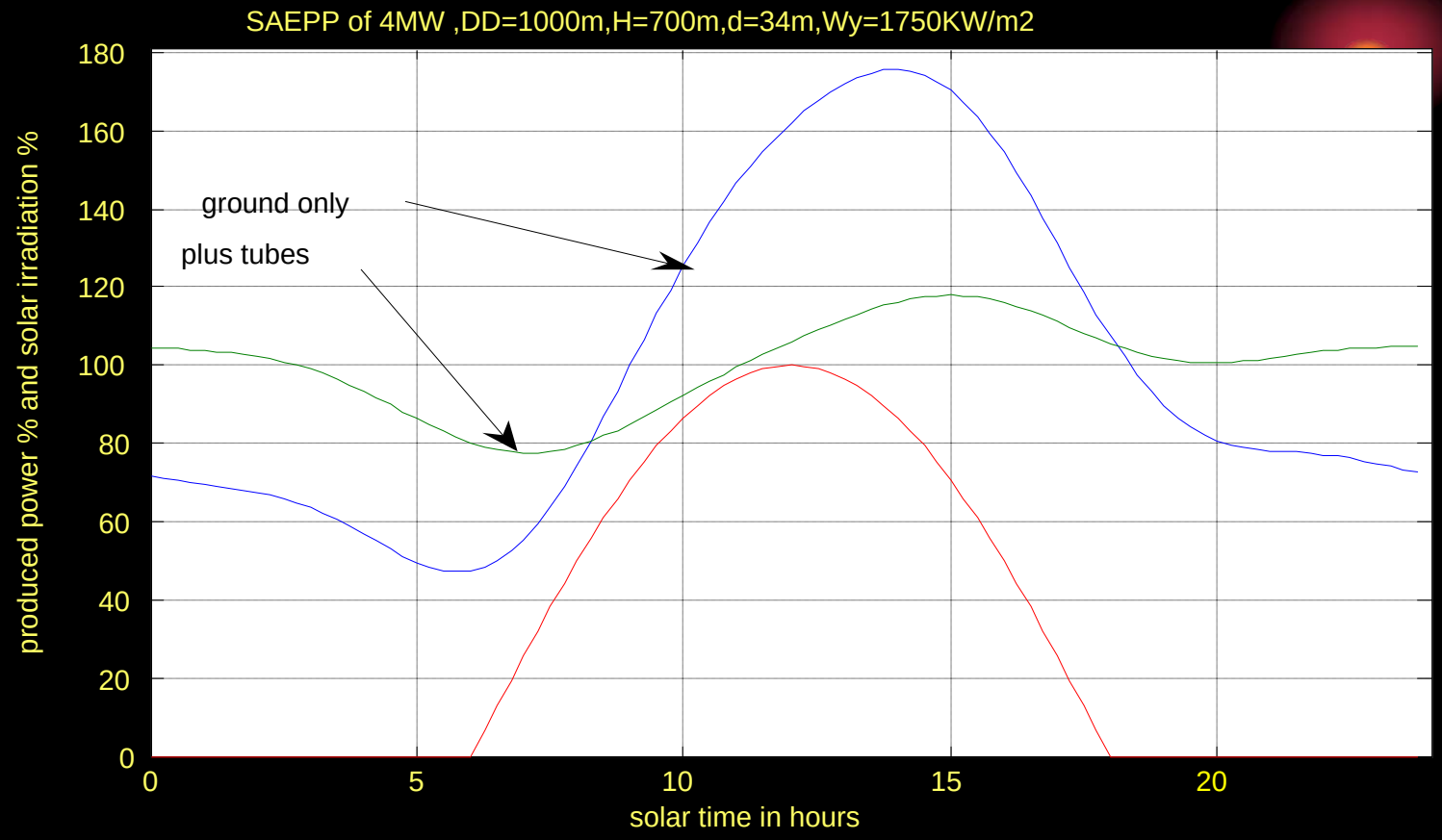


A small part of the main body of the Floating Solar Chimney



Solar Chimney power plant daily operation

-Ground only **(blue)**
-Ground plus artificial thermal storage **(green)**
-Solar irradiance % **(red)**

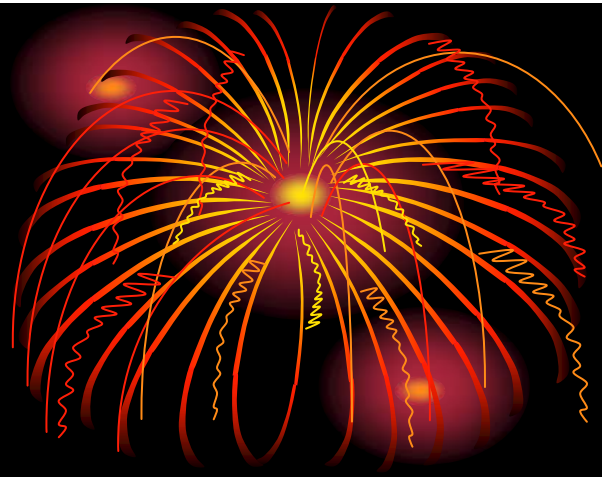


FSC power plants investment cost

- The FSC technology has much lower investment cost (1/4 of CSP technology i.e. approximately 500000 EURO per produced GWh/year)
- The direct production of KWh will be ~0.06 ΕΥΡΩ (25 year operation of the plant, loan with interest rate 6.5% + OM~0.015-0.02 EURO/KWh, in the maintenance cost the periodic replacement of the FSCs is included)
- The FSC technology has many benefits beyond its far less investment cost, however it has not yet been tested at a demonstration project

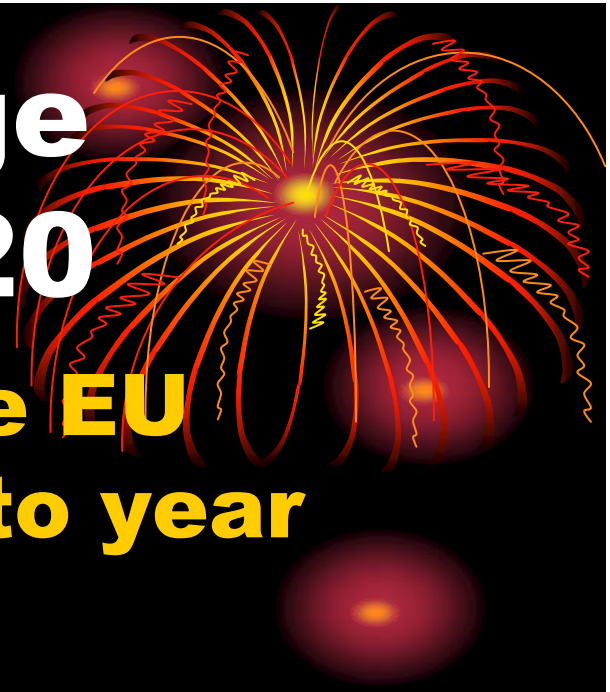
Solar Technologies Cost Comparison

Technology of Uninterrupted Electricity Power Supply	Capital Expenditure per Produced GWh/year In Million EURO	Direct Production Cost Per Produced MWh/year In EURO
Photo-Voltaic and Batteries	**>3.0**	**~300.0**
Parabolic Through CSP and Thermal Energy Storage	**>2.0**	**~200.0**
Floating Solar Chimney Ground Thermal Storage	**>0.5**	**~60.0**



3. EU policy of 20-20-20 up to 2020 is in the right direction but it is not enough

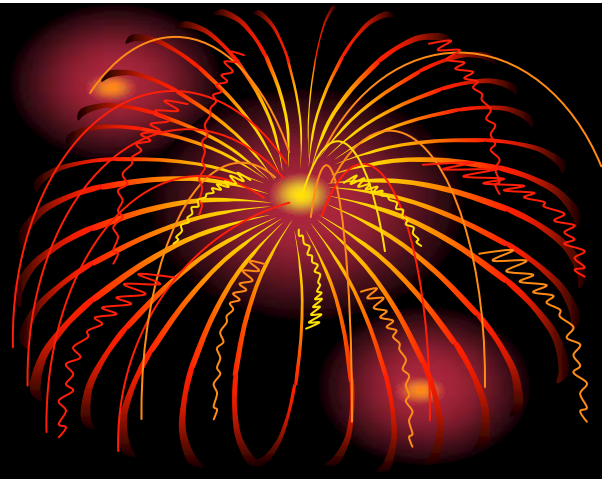
EU climate change policies up to 2020



- Three targets characterize EU climate change policy up to year 2020:
- Decrease in greenhouse gases up to 20%.
- Electricity generation and end energy use up to 20% by renewables.
- 20% increase in energy efficiency.
- 20 – 20 – 20 up to 2020.

The 20-20-20 policy is necessary but not enough

- **The EU policy should be competed with the Desertec plan**
- **The Desertec plan anticipates massive solar electricity generation in MENA area and transmission to EU.**
- **This should become a EU target "in the context of EUROMED energy policy"**
- **Adopting Desertec plan EU will be the right way to save the planet**



4. Desert Electricity Generation in EUROMED context

The Desert Electricity data

- Every square meter in the desert or semi desert lands of MENA area receives solar energy of 2000 KWh per year, as an average.
- With the existing solar technologies we can transform easily more than 1% of this solar energy to electricity.
- This means that from every square Km of desert or semi desert land we can generate electricity at least 20 GWh , which is enough to cover the needs of a city with 7000 population.

The importance of Desert Electricity for EU

- If we assume that we would like to cover 40-50% of the EU needs in electricity, using desert areas, we should generate 1250 TWh
- In order to achieve it, we should use a desert or a semi desert land not more than 62500 square Km or a square land of 250km X 250Km
- 40-50% coverage in year 2030 means 1600-2000 TWh and a square land of 300 Km X 300 Km is necessary (efficiency 1%)

Land for 40-50 % of electricity of EU (1% efficiency)

The electric transmission lines for Desert Electricity

- The proper transmission system is the UHVDC
- Using DC lines of ± 800 KV we can easily transfer the solar electricity to South Europe and to the rest of Europe
- These DC lines can be overhead, underground or undersea without any problems
- The power losses are less than 3% per 1000Km and their average construction cost, including the terminal stations of AC-DC and DC-AC, will not be more than 1.0-1.5 billion EURO per 6.4 GW and >1000 Km distance

5. Investing in Desert Solar Electricity

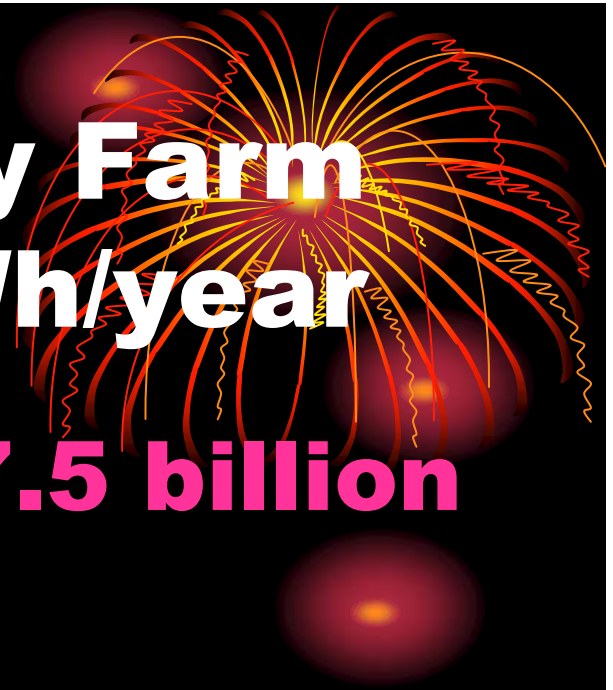
Electricity generation in North Africa and transfer to Europe

- In the context of EUROMED any group of proper companies could lease a desert or semi-desert land where a large farm of FSC technology power plants could be constructed
- The generated electricity could be transferred to South Europe through UHVDC lines (±800 KV)

An Autonomous FSC technology farm of 6.4 GW

- Why 6.4 GW ? (±800 KV, 4000A)
- How many SAEPs of 4MW, 1sqKm,18-20 GWh (1600 pieces)
- Annually generated Electricity in GWh (29-32 TWh)
- Land (1600 sqKm 40KmX40Km)
- Construction Cost (16 billion EURO)
- UHVDC Transmission Lines Cost (1-1.5 billion EURO)
- Transmission Losses/1000Km (3%)
- Net Power to the AC grid 28-31 TWh (Reference 30 TWh)

The FSC technology Farm for 6,4GW and 30TWh/year



- **Capital Expenditure 17.5 billion EURO**
- **Interest Rate (6%)**
- **Depreciation period (40 years)**
- **Annual repayments (1.2 billion EURO)**
- **Cost for Replacement of FSCs fabric part (1600X1.6/6)= ~0.40 billion EURO)**
- **O.M. cost per produced KWh (~ 0.2 billion EURO)**
- **Direct Production Cost (1.8 billion EURO)**

FSC technology Direct Production Cost

- **Direct Production Cost of MWh in EURO cents analyzed to:**
  - **Capital Cost 40 EURO/MWh**
  - **O.M. cost 20 EURO/MWh**

~ 60 Cents of EURO /MWh

Solar Desert Technologies PP of 6.4 GW and 30TWh/year

Technology of Uninterrupted Electricity Power Supply	Capital Expenditure In Billion EURO	Direct Production Cost Per Produced MWh/year In EURO
Photo-Voltaic and Batteries	**>90**	**~300.0**
Parabolic Through CSP and Thermal Energy Storage	**>60**	**~200.0**
Floating Solar Chimney Ground Thermal Storage	**>17.5**	**~60.0**

The project for Greece

- The project of generating 25000-30000 GWh/year and transmitting it to Greece it will demand funds of ~17.5 billion EURO
- If the Greek government could guarantee the selling price of electricity by this project for the next 30 years, I am sure that this plan can be easily financed by private funds
- PPC could participate in this plan as Greek and foreign construction companies would participate

Transmission to Greece

It is our duty to take all the proper decisions in order to keep the increase of global temperature below 2 oC

In order to generate 50% of world electricity demand less than 3% of desert and semi desert lands of our planet are enough !!!

- The annual electricity demand is (year 2008) ~20.000 TWh
- A respectable part of the produced ~28 billion tons CO2 is coming from fossil fueled electricity generating technologies
- The annual electricity demand will be doubled in the next 30 years. In 2040 the estimated electricity demand is ~45.000 TWh
- The electricity generation by all “clean” technologies is not estimated to be more than 50%
- A large scale application of the Floating Solar Chimney technology in desert or semi desert areas could generate the missing 50% of electricity demand (20000-25000 TWh), cost effectively, eliminating the global warming threat

Major reference sources

- *An excellent presentation of the climate change and the mitigation policies is given in the documents of Intergovernmental Panel on Climate Change (IPCC)*
- *IPCC information through key word IPCC http://www.ipcc.ch*
- *EU information through the key words EU energy http://www.energy.eu*
- *USA information through the key word DOE USA http://www.doe.gov*