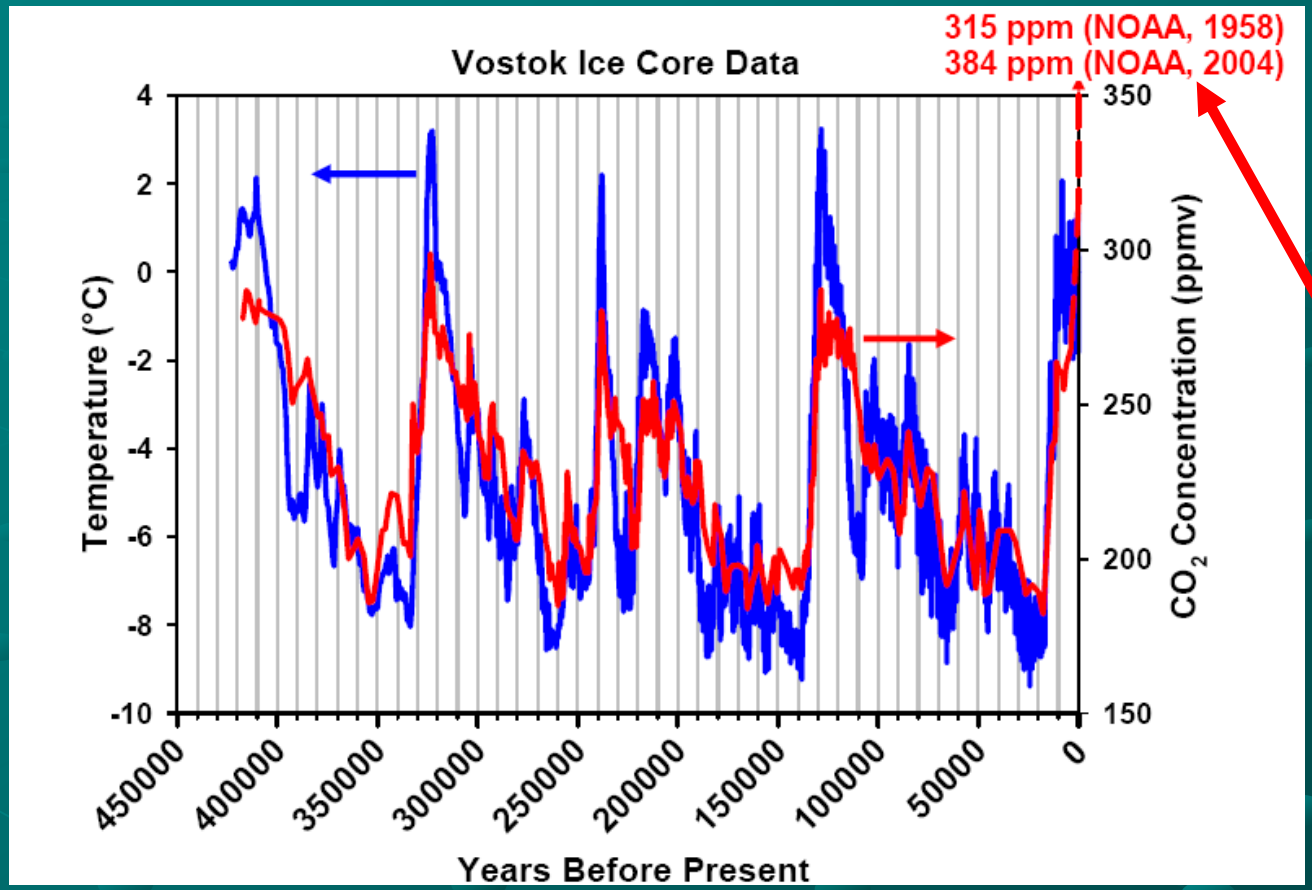
PROTEAS SOLAR TRIGENERATION CONTRIBUTION TO THE GREEK GRID SYSTEM SMOOTH OPERATION, SECURITY AND CHANGE INTO A 40% SOLAR ONE

HELIOTRON INSTITUTE FOR ENGINEERING AND R + D

December 2013

Climate Change



CO_2 is the Highest in Recorded History.

Last Year surpassed 400 ppm !

Antarctic Ice Core Data allows for Temperature and CO2 Profiles Mapping of past hundreds of thousand years

Stern Report

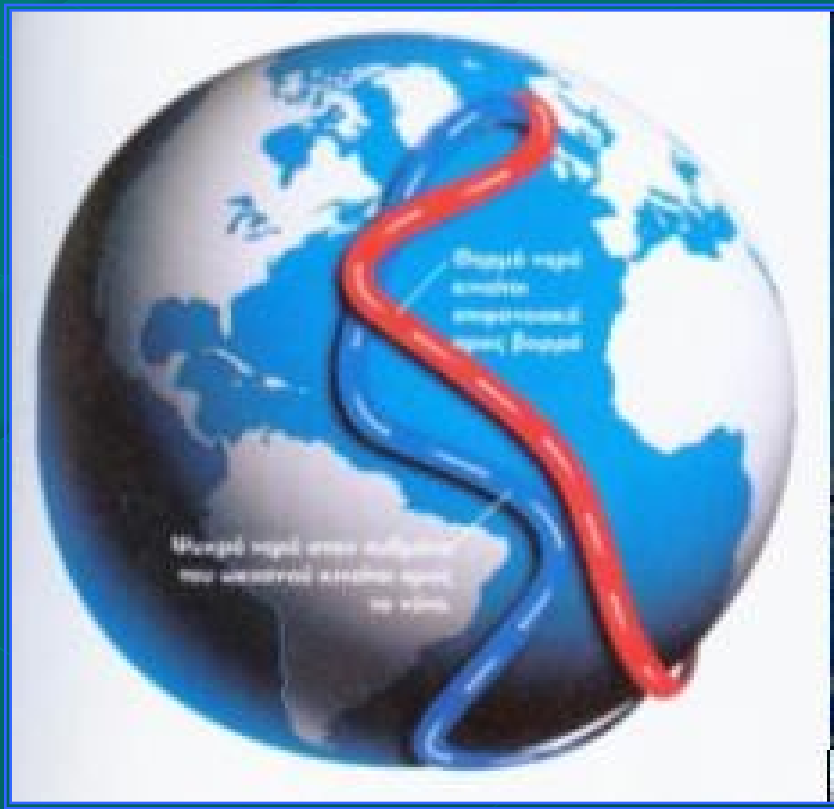
« Climate Change presents a unique challenge for economics: it is the greatest and widest - ranging market failure ever seen!»

Last update by Nicholas Stern:

"I have made a big mistake : Climate Change Danger is not that bad . It is much worse"

Warning Facts

Oceans Cooling Stream Velocity is reduced from 6.0 to 4.8 Miles/Hour
Climate Change is here! Too Late?



Window of Opportunity

« The Window of Opportunity to close the CO2 Gap for 2oC is Narrow and closes very quickly. We have less than 10 years to react decisively and to reverse the CO2 increase curve by 50% up to 2030 and 80% by 2050 as of 2009 level»

Reactions

1. Panic

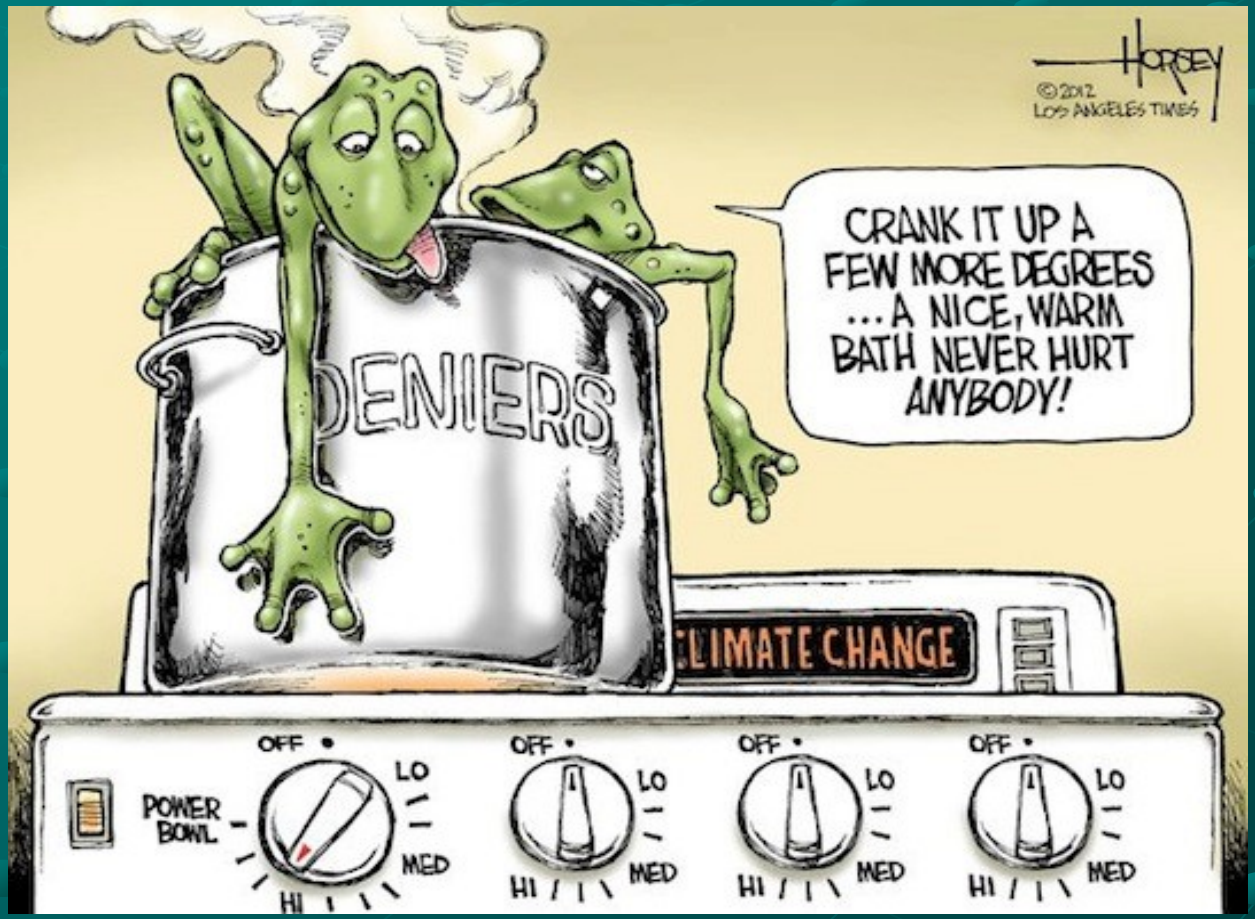
Reactions

2. Do Nothing

Reactions

3. Share Deniers' Destiny

NOTE : NEXT " CRANK UP BY A FEW DEGREES" IS "POWER BOIL"!



Reactions

4. Fight the Climate Change with PROTEAS "Cost Free" Weapon !

Reactions 4 (cont.)

Fight the Climate Change and by the way make a Fabulous Profit. PROTEAS Business Opportunity is able to remove the debt of Greece and whole Europe including that of USA and clear the sky of China, India, and RoW within the next 20 Years. It is the best and widest Business Opportunity ever seen.

Global Renewables 2008, 2009,2010,2011,2012,2013

- World invests on average around 300-400 billion pa on energy projects of any type – conventional and renewables (Bloomberg GTR-UNEP).
- 2008 – world invested more in total on renewable energy ($155 billion) than on traditional energy ($140 billion).
- Almost 50% of new generation built in 2009 was renewable energy 80 GW of renewable power compared to 83 GW of fossil fuel plants.
- 2010 up 32% with $211 billion investment in 2010.
- $279 billion in 2011, up 25% on 2010 - 5 times 2004, $244 billion in 2012, 12% down from previous year $279 billion but 8% up of 2010 plus $33 billion for large hydro plants.
- 2008 IEA forecast build for coal globally was 64 gigawatts - actually built in 2010 was 14 GW (built of solar in 2010 was 17 GW!)
- Given that as of 2013 FITs are lowered, PV cost must enter parity to conventional KWH cost, in order to keep or increase the momentum of the last years.
- However the needed target of several thousand GW and several trillion Euro in order to fight the CO_2 and the Climate Change is still far away.
- PROTEAS can accomplish and exceed by far this task. PROTEAS can provide the needed thousands GW without investing the trillions Euro

WORLD - EU REACTION TO CLIMATE CHANGE I

- Feed In Tariff (FIT) born in Germany has accelerated the transition of PV into a competitive Energy Source in the last years.
- The DESERTEC Project was designed for 160.000MW Solar in North Africa to provide solar electricity to Central EU States.
- Political and Technical reasons impose the need of transportation of DESERTEC to South EU Countries like Greece, Spain, France, Italy.
- Greece is the solar favored South EU State, shares the same Parallel with Algeria in Africa, being inside EU, one third the transmission cost, with higher PV and Wind Yields being both supplementary.
- Project New HELIOS of 10.000MW in Southern Greece is designed as the first step of the New DESERTEC in Southern Europe.
- USA could implement similar Projects in the vast sunny deserts of the Southern - West States. USA DESERTEC in New Mexico, Nevada, ..
- PROTEAS needs no FIT, even without Trigeneration, targeting only electricity in remote sunny areas, PROTEAS can provide parity.
- KWH cost of 0.06€/KWH is feasible and use of Ultra High Voltage Transmission Lines secure connection with 3% losses each 1000 km to remote centers of consumption: Central EU, East China, USA.
- PROTEAS Solar Trigeneration is totally self-financed. Negative FIT!

PROPOSED REACTION TO CLIMATE CHANGE II

- Project NEW HELIOS in Peloponnesus with 10GW Capacity can be the First Phase of Desertec Transfer to Southern Europe.
- However the recent relative Law 4062 /2012 is complicated and must be simplified and the transmission line be part of EU transgrid
- The recent advances in PROTEAS PV Technology are much more efficient, cost competitive & giving new perspectives and feasibility
- Electricity prices of 0,09€/KWH sold in Germany and rest Central Europe including transmission losses are feasible.
- Transmission Lines of +/- 800KV DC present losses of 3% per 1000km at reasonable cost up to Agona Transmission Hub in Italy
- International Investors of World Dimensions are interested to be involved in the New HELIOS providing both finance and expertise
- Investment cost is estimated to 13-15 Billion€ shared by EU - USA
- Synergies with Wind Parks and one-day compressed - air storage can provide more than double transmission line load-factors.
- In addition can be bridged the gap of PV night supply, providing in parallel a reliable 24-hour grid supply-system. Grid Reliable PV!

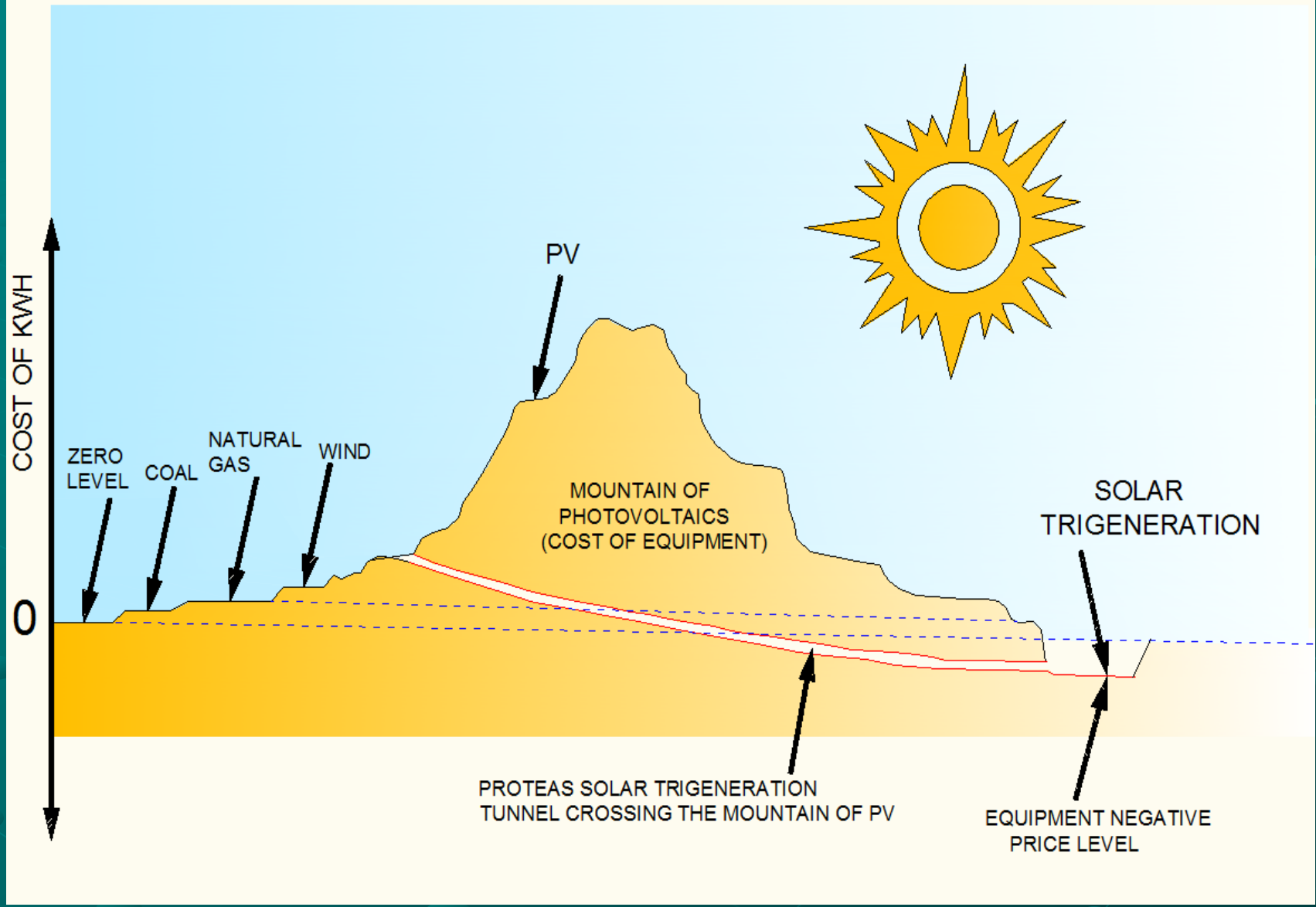
PROPOSED REACTION TO CLIMATE CHANGE III

- **First Phase the already signed GSRT Demonstration PROTEAS Solar Trigeneration Project of 3.0 Million €**
- PROTEAS Tracker Version will be tuned and certified for Commercial Multi-MW Projects without the Heat Pump
- A Commercial PROTEAS Tracker Project, in preparation in the MW scale, with innovative submarine compressed air storage, increasing capacity will follow.
- In parallel other PV Projects around the Globe will be proposed (EU, USA, China, Australia, India, Mexico, ..)
- USA can implement its own in the deserts of Texas, New Mexico, California and Nevada: The USA Desertecs.
- **These Multi-MW PROTEAS Projects reaching parity will help keeping or increasing the momentum of PV.**
- **But PROTEAS Solar Trigeneration Ultimate Proposal is the Cost-Free Infiltration of Solar Energy by more than 50% in the energy mix of most world countries.**

THE CLIMATE – CHANGE PROBLEM AND THE "COST – FREE" PROTEAS SOLUTION

- The Climate Change Problem:
- The world scientific and industrial community is fighting hard to climb and conquer the cost and technology Mountain of Photovoltaics (see next slide presentation).
- Thousands of PV troops are trying to climb the Mountain and dream to conquer the opposite side, promising clean, cheap and abundant energy, with price levels lower than fossil fuels and avoiding the Climate Change.
- But the Mountain is very high, precipitous and hostile and in spite of brave attacks, generous state and private incentives and support, the promised land of clean, cheap and abundant energy is still far away, while the nightmare of Climate Change is coming closer at an accelerated pace (Katrina, Sandy, Polar Ice Melting,..)
- Time is short and the money required to build the new solar infrastructure is beyond any imagination. Maybe, when found and implemented, the Climate Change will be non reversible (some experts are arguing that it is already too late! See Stern Report and recent findings).

GRAPHICAL PRESENTATION OF TRIGENERATION FEASIBILITY



THE CLIMATE – CHANGE PROBLEM AND THE COST – FREE "PROTEAS" SOLUTION

Proteas Solution:

- In our Heliotron Institute we didn't have the troops and means required to conquer the Mountain, but we have been keen and lucky enough to discover a passage and a hidden tunnel under the Mountain of Photovoltaic, which has led us to the other side into an unexpected land with unique features and unparalleled business opportunities. Sun is shining and smiling friendly in this magic Land.
- **We have named this unexpected magic land "The Land of Free Investments with Prepaid Profit".**
- Our Proteas Photovoltaics, when implemented in this Land, are not only competitive to Wind and other Renewables, they are not only competitive to any fossil fuel fired derived electricity, but they are credited several times their investment cost and much more surprisingly they enjoy this credit - payment 2 or 3 or more years before the commissioning of the PV investment. **Not only cost-free but prepaid several times. An unexpected "Cost - Free" Weapon against Climate Change**
- **I invite You for a walk in the Magic Land of Free Investment with Prepaid Profit. Enjoy it!**

PROTEAS SHORT HISTORY

- PROTEAS has been invented, patented and developed by Mechanical - Electrical Engineer NTUA Alexandros Christos Papadopoulos.
- PROTEAS has won the First Prize of Technology from the Intellectual Property Organization (OBI) in 2004.
- It has been developed in the frame of one European and two National R+D Programs with a total value of 4,6 Million Euro.
- Patents are issued or pending in Europe, China, India USA and Australia after an 8-10 years adventure.
- An Industrial Prototype has been developed in the frame of the last National R+D Program.
- A new National Program in the frame of NSRF has been submitted in July 2011 in cooperation with NTUA, TUC (Technical University of Crete), IOBE and three other Partners and has been evaluated / signed for financing.
- Target of the NSRF Program is final tuning, certification and concept Pilot Production Line of PROTEAS Unit.

Why is Proteas Self-Financed

- Utilities in the Sun Belt suffer from severe Peak Power Problem due to Air Conditioning Loads during Summer
- Each KWp Proteas Solar TRIgeneration shaves (cuts-off) up to 5,0KWe of Utility Peak Power (Load x1,2)
- The cost of the shaved 5,0KWe plus cost and losses of avoided Transmission / Distribution Lines, plus the cost of avoided O+M, offsets by far and in advance the cost of the 1,0 KWp of Solar TRIgeneration of the Utility using Proteas TRIgeneration Technology.
- The Utility, in addition, exploits the "Self - Financed" Solar TRIgeneration's energy yields for more than 25-30 years, avoiding in parallel 6-8 TonCO2/kWp.Year
- Solar TRIgeneration is specially suited for countries with islands (Greece) or high coal – fired capacity (China, USA, Australia, India, South Africa), where Peak - Power avoided cost will offset PROTEAS cost
- Below is given a PROTEAS application case for USA

A "Cost-Free" Transition into a Solar USA within the next 20+2 Years

- Below the case where USA Utilities install Proteas PV by Leasing on their Clients' Roofs of Typical 200m2 Houses in San Jose (about 2200ft2 aver.)
- Foreseen to accommodate an average of up to 10 A/C Units at the end of the next 20+2 years rated at an expected 12,5 KWe Peak A/C Load per House
- The Houses are estimated to create A/C Peak-Loads of 25.000.000x12,5KWe = 312.500MW at the end of the 20+2 years time from now (2035) mainly due to Air-Condition plus some minor usual electric peak - loads = total 325.000MWe.
- Total PROTEAS Capacity required to replace or cut-off this Peak-Load equals to 325.000 MW / 5 = 62.500MW equal to 2,5+0,5=3,0KWp PROTEAS/ House
- The value of energy generated by these 62.500.000KWp shaving peak-loads, installed with linear increase from year 2015 till year 2035, is equal to this one of 31.250 MWp equally distributed for all 20 years from 2015 till 2035.
- If only half of the value of the energy generated as above would be decided to be reinvested in new PROTEAS capacity, then the 62.500MW will finance the installation of 83.984 MWp new PROTEAS capacity within the 20 -1=19 years
- The same repeated by the 83.984MWp will produce 107.210MWp in 18 years and so on to reach an additional 1.370.700MWp in these 20 years (see Table)
- This is a Total of 1.433.200MWp of PROTEAS capacity installed as "cost-free" (with self-financing by reinvesting only 50% of the produced value of energy).
- **Although a rough approximation, the analysis shows the potential of PROTEAS Cost-Free Transition into a 50% Solar USA Economy**

Comparison with Conventional PV

- 5,0kWp Conventional PV on a 2200ft2 House in San Jose:
- Annual Energy Yield: 3,0x1.600*= 4.800KWH/Year
- Cost of 3,0KWp Conventional PV: 3,0x $1800 = 5.400$
- Value of PV Electricity: 4.800*x0,125$/KWH= 600$/Y
- Production of Green Certificates: 4.800x0,8= 3.840Kg/Y
- Value of Green Certificates:3,84Tx 25$/T (future)= (96$/Y)
- Substituted Components New House (3,0KW UPS): 800$
- Substituted Components Exist. House (3,0KW UPS):800$
- Shaved Peak-Power per 1,0KWp Conventional PV: None (No storage) (Compared with 5 -10 Hour Proteas storage)
- Net Annual Utility Profit per House:0,95x600=570,0$/Year
  Capital-O+M cost of PV:(5.400-800)x0,14=644$/Y>570$/Y
  Non feasible without FIT (No comparison with Proteas PV)
- * Fixed PV average yields in Southern California. We assume collective O+M by Utility for comparison reasons

SOLAR TRIGENERATION

IS SELF-FINANCED BY PEAK – LOAD SHAVING AND CAN BE RIGHT HERE AND RIGHT NOW APPLICABLE WORLD-WIDE WITHOUT ANY INCENTIVES

A MARKET - DRIVEN UNIQUE BUSINESS OPPORTUNITY AND A "COST FREE" WEAPON AGAINST CLIMATE CHANGE

PROTEAS BENEFIT BEYOND OF REINVESTED SOLAR CAPACITY

- EU-USA Houses suffer from value degradation and red loans which have created the big housing bubble with consequences and economic crisis worldwide.
- The addition of 3,0KW PROTEAS capacity to each average House as above and instead of cost for the House Owners adding a cumulative profit of 9.800+5.076= 14.876$ in 20 years, will help the housing market to recover and be profitable.
- PROTEAS Solar Trigeneration can change Houses into Climate Change Fighters
- Change EU - USA's Energy Profile from coal and natural gas addicted into more than 50% solar in the next 22 years practically "cost-free" or by self-financing
- Create practically zero CO2 emission and energy independent houses and buildings with high standards of air-conditioning and heating
- Create a clean and healthy environment safeguarding the health and prosperity of the EU-World people. Savings from avoided pollution health problems equally big.
- Fight the Climate Change and minimize CO_2 emissions on a Global scale and importance. Developing Countries can be equally or even more benefited.
- Create production of Solar Hydrogen for Hybrid Cars and rest needs
- Do all this transition by self-financing or cost-free creating in parallel an important income from the Sun for the implementation of Solar Energy by people in need
- Help making Utilities highly profitable and able to capitalize with big profit from the transition from coal and oil into a zero CO2 solar economy.
- Protecting the Environment needs no subsidies any more. It is a highly profitable Business Opportunity of Global dimensions and importance. No trillions € wasted

SMOOTH OPERATION OF THE GREEK ELECTRICITY SYSTEM

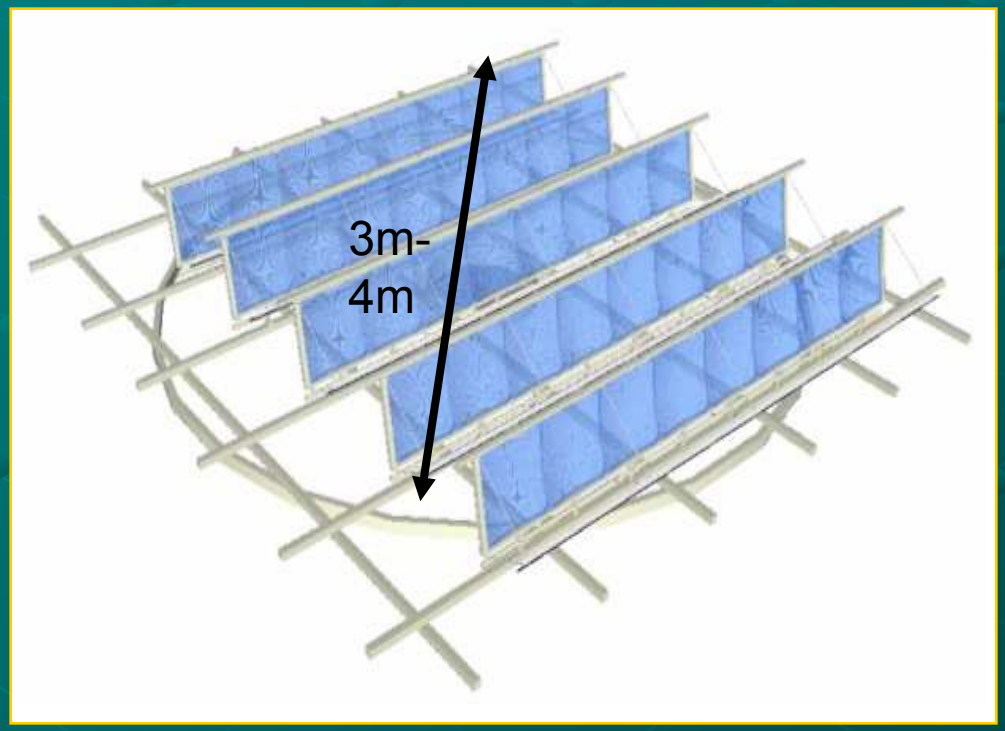
- PROTEAS Solar Trigeneration can store cooling energy for operation of the air-condition also during the night, thus avoiding peak load and intermittent operation and so contributing to the system smooth operation.
- PROTEAS needs no FIT, even without Trigeneration, targeting only electricity in remote sunny areas, KWH prices of 0,06€/KWH are feasible and thus PROTEAS can provide parity.
- Project New HELIOS of 10.000MW in Southern Greece can be competitive and thus be designed / implemented as the first step of the New DESERTEC in Southern Europe, followed by further steps equally important .
- The Greek Electricity System will have thus secured a strong interconnection to Central European Grid thus increasing its safety and stable and smooth operation,

Prototype Solar TRIgeneration Unit

The System Characteristics

➲ Solar TRIgeneration System

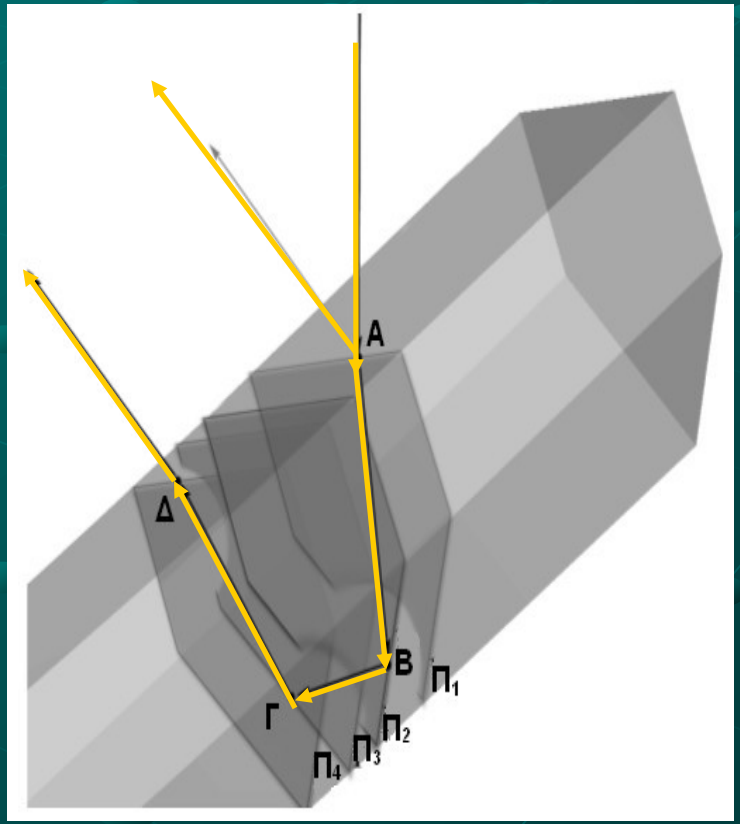
Production of: Electrical, Two-level Thermal and Cooling Power
Typical Unit: 1000Wp | 250-500Lt Hot Water | 8000-16.000BTU | 500-1000Lt Warm Water. World Patent Total Internal Reflection Reflectors



- Innovative Optical System
- Concentrating III-V PV Cells
- Advanced Absorption Chiller
- Low Cost Alu Metal Frame
- Low Profile Tracker System
- Advanced Control System

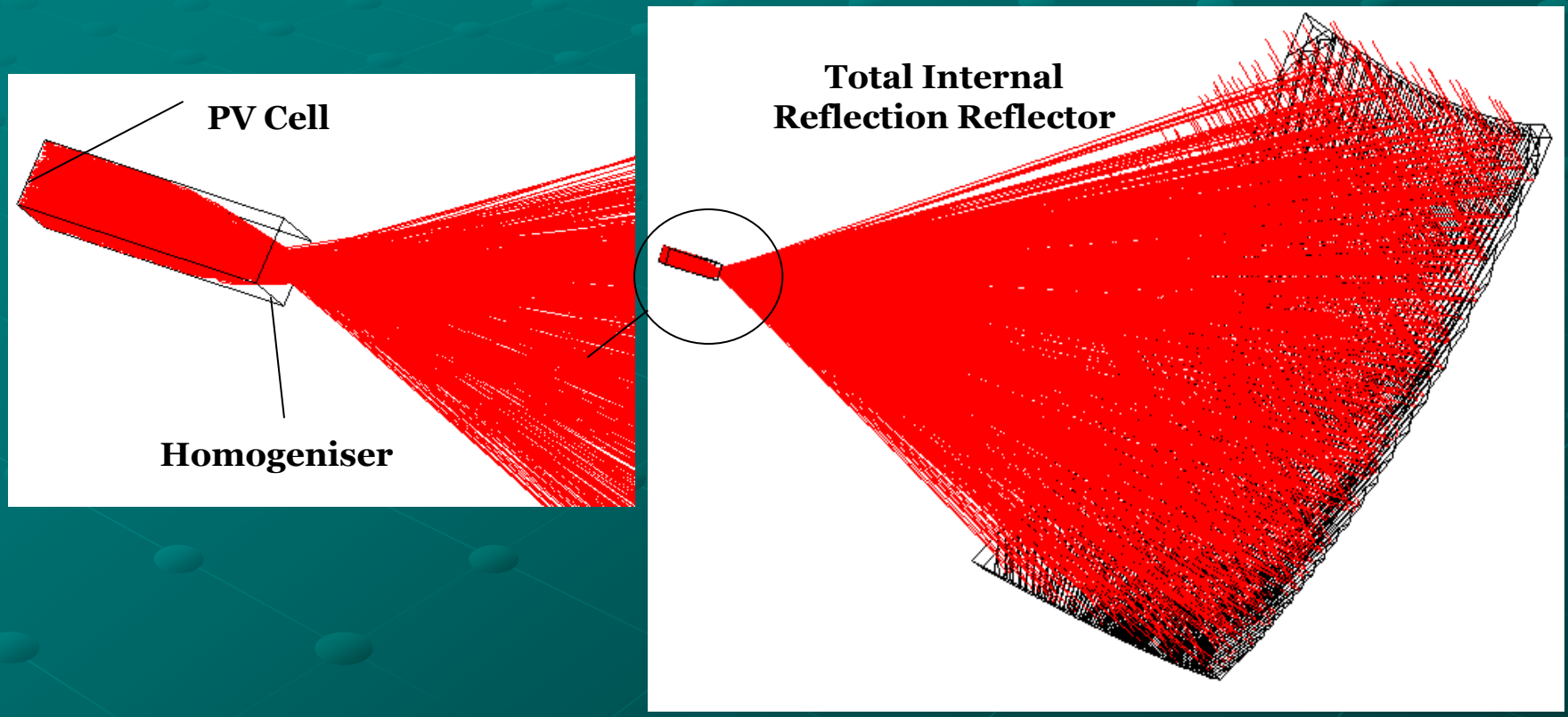
Total Internal Reflection Prisms

- Constructed as a Total Internal Reflection Reflector with Corrected Orthogonal Prisms
- High Concentration Point Focus 1:5000 through Total Interrnal Reflection of Sun-Light
- Material: Water-Clear Glass or PMMA or Polycarbonate

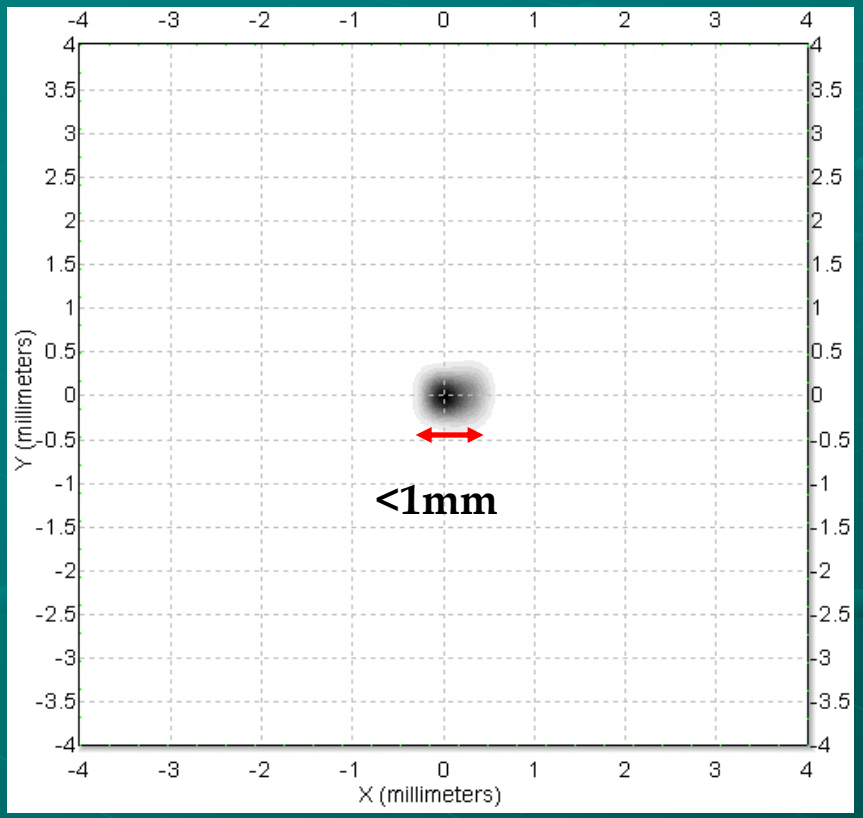


Total Internal Reflection Reflector (TIRR)

Ray Tracing Simulation

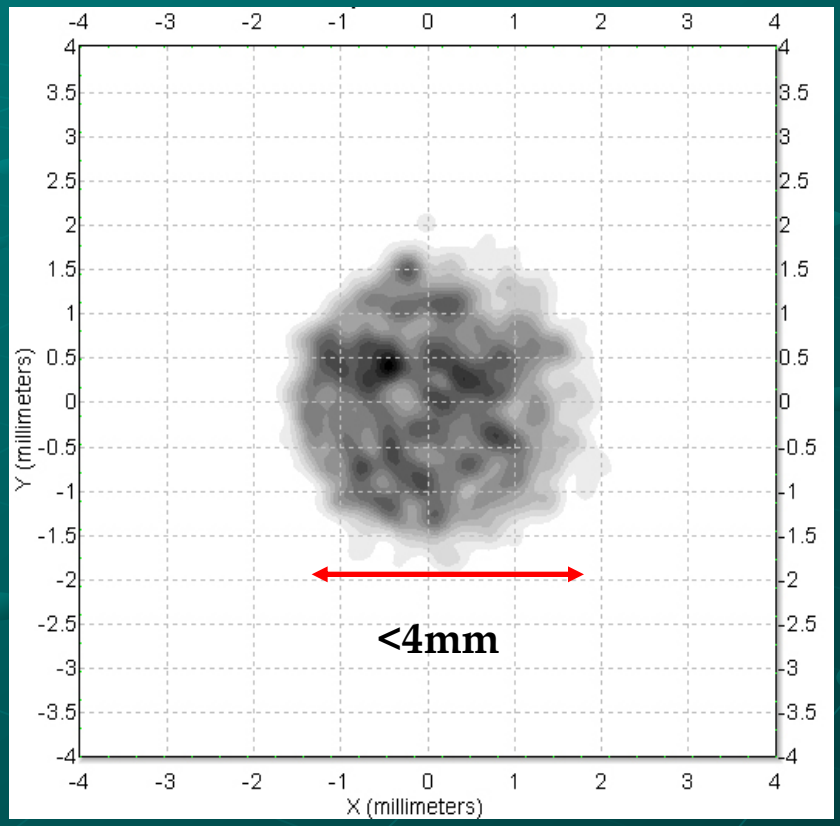


Ray Tracing Simulation Results



Geometrical Distribution

1:90.000

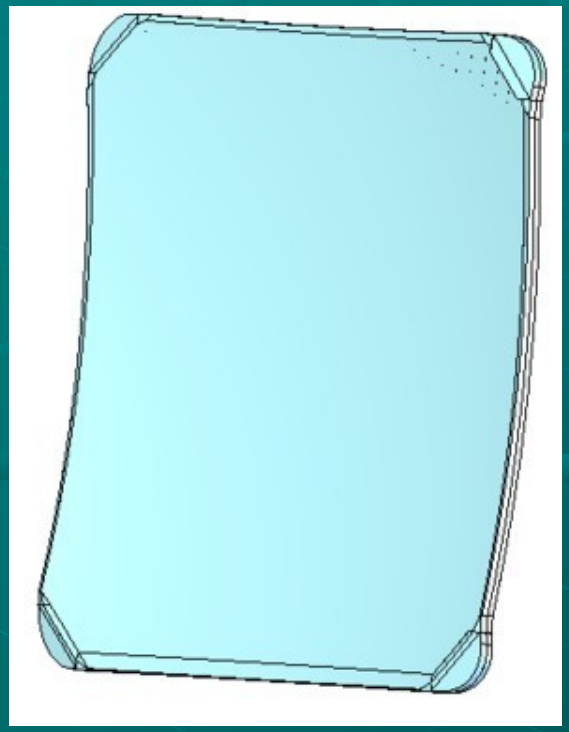


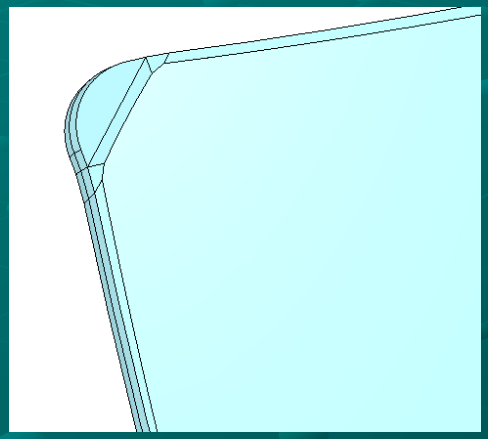
Solar Distribution

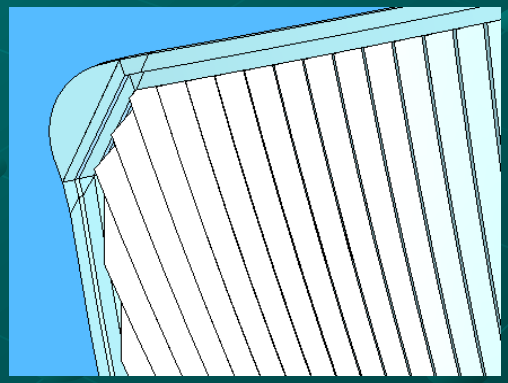
1:5.000

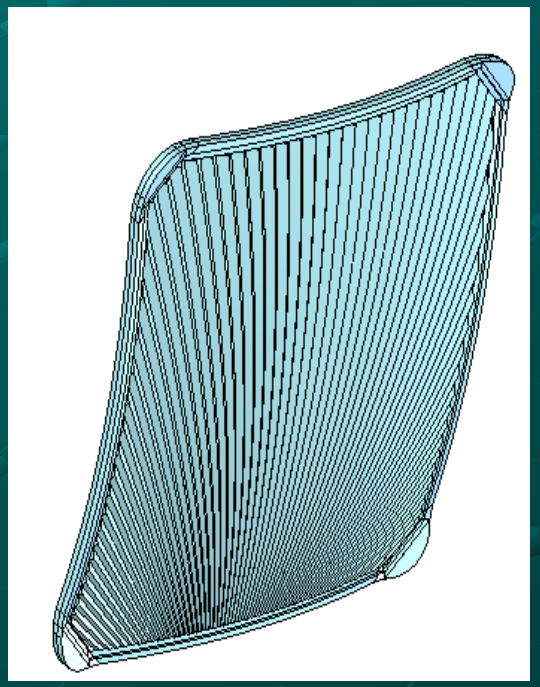
Final Design for the TIRR

- According to Glass Industry Restrictions



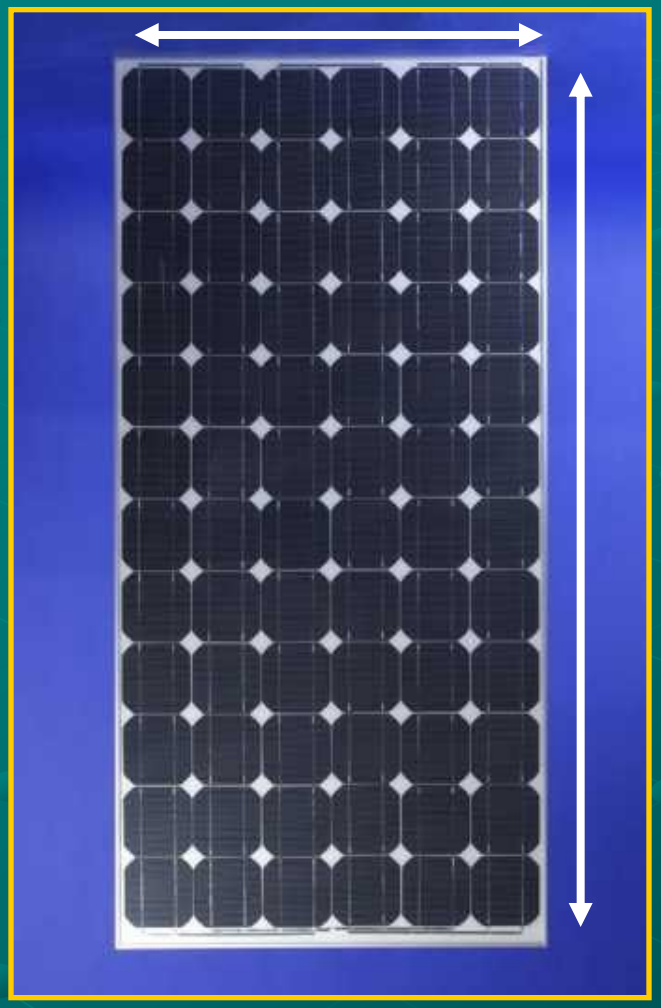






TIRR Glass Prototype in the Press

Concentrating Type PV 1:1000

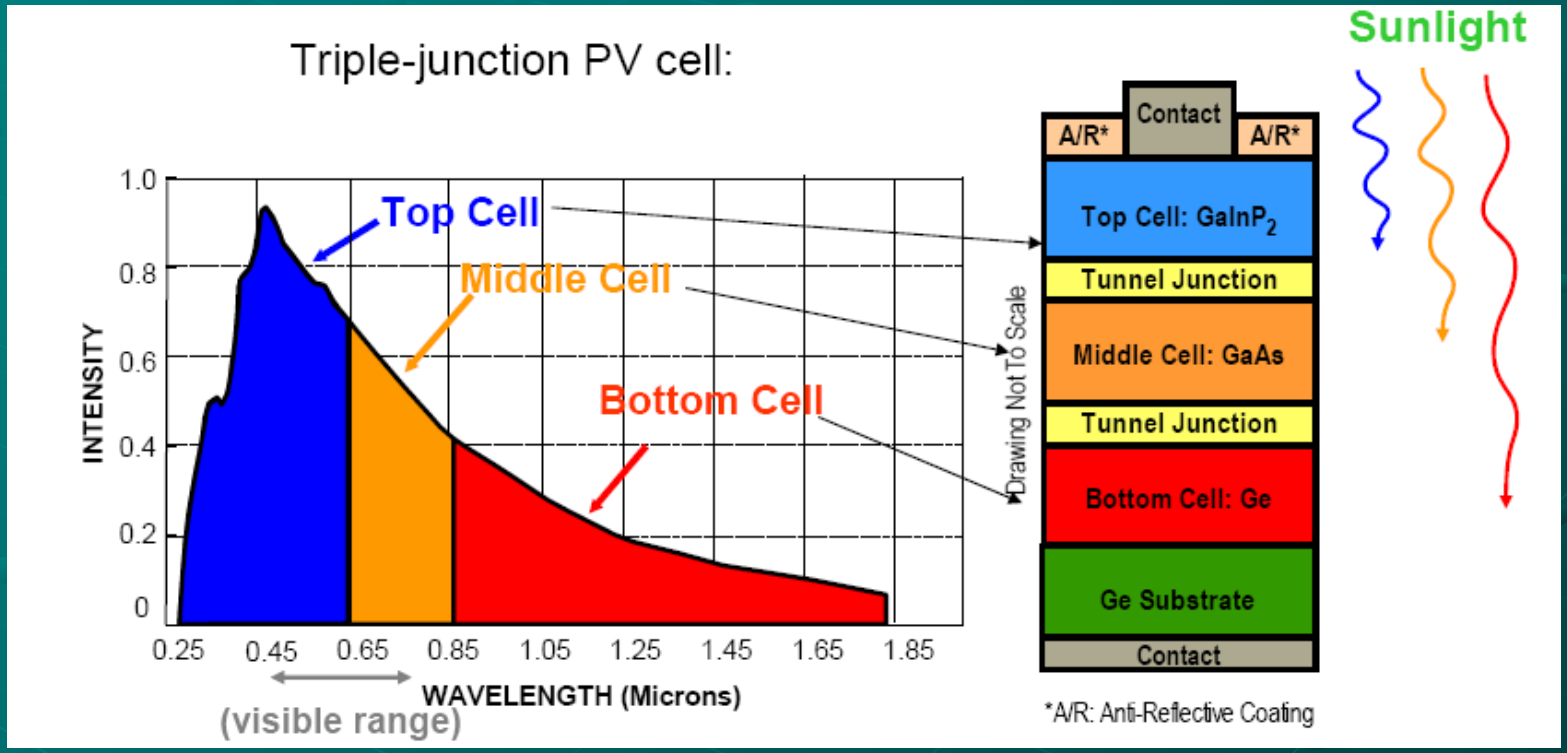


60 x 120cm

100Wp

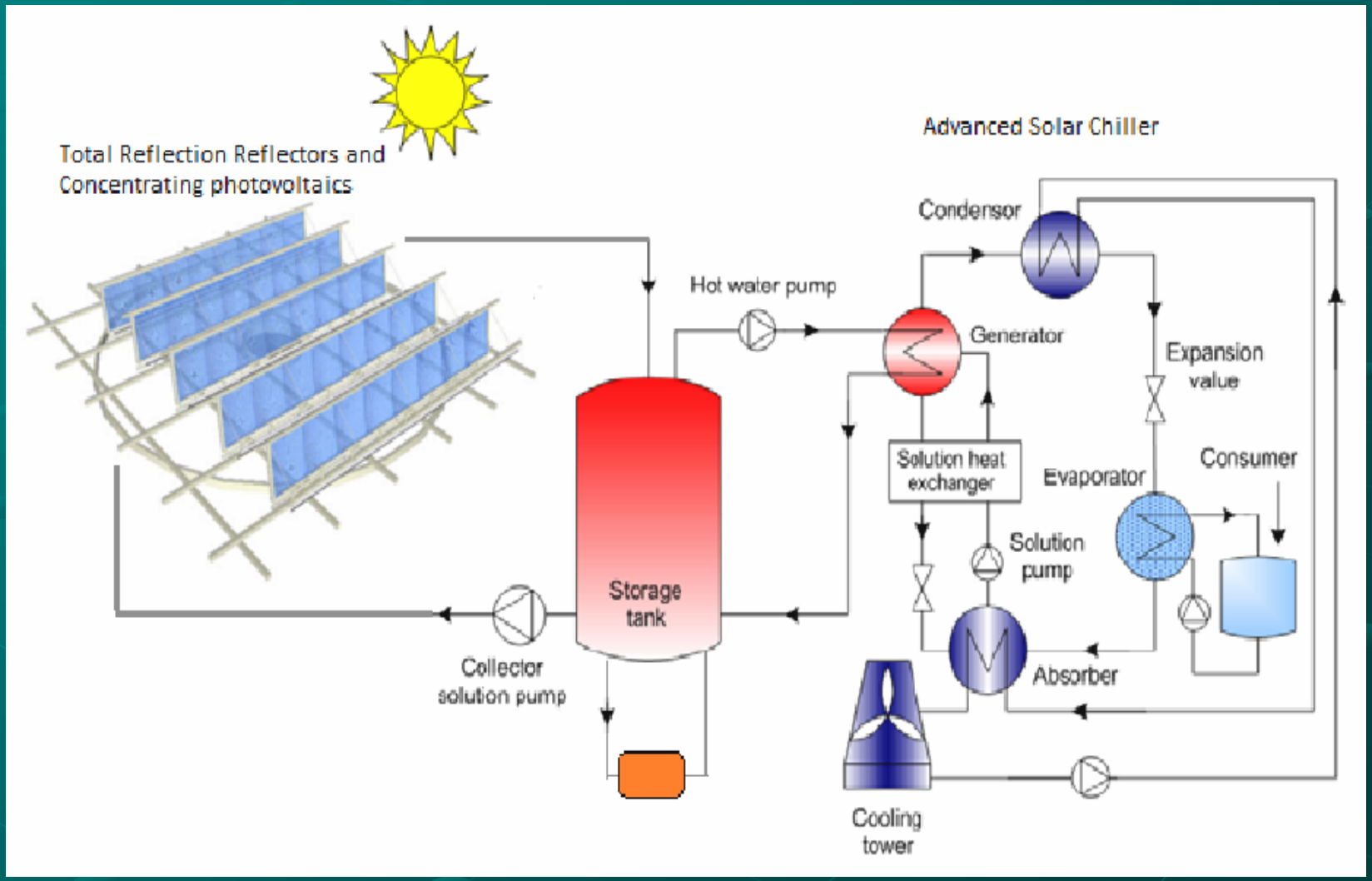
2,5 x 2,5cm

High Efficiency Multijuction Solar Cells of Spectrolab, n>40% , 20 years Warrantee



- Sandwich of materials divides the solar spectrum to maximize efficiency
- Power is a product of voltage and current
- Each junction adds voltage; current between junctions is matched in monolithic cells.
- Presents almost half the temperature coefficient of flat plate crystalline PV modules
- Suitable for efficient high temperature (80-95 degrees) operation and hot water yield

Schematic Representation of PROTEAS Solar TRIgeneration System



Reflector Package- Connection Profile

Secondary Optical System & Heat Sink Built

Concentrating Array (Front View)

TIRR Molding for PMMA Production

Sun Tracking System Actuators/Tracker

AKNOWLEDGEMENT-THANKS OF SOLAR POLYGENERATION

- The Prototype presented above has been made in the frame of the Programme PEP-ATT-73 of the GSRT in cooperation with PPC – KDEP and the National Technical University of Athens - School of Chemical Engineers
- Many Thanks are expressed to All who have cooperated in the realization of this Programme especially to General Secretariat of Research and Technology and to the Ministry of Development for their encouragement and support.

Thank You!