



# **SOLAR THERMAL UTILIZATION PAST PRESENT AND FUTURE**

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BANGALORE**

| Report Documentation Page                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                    |                                     |                                             | Form Approved<br>OMB No. 0704-0188          |                                    |
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# WHY SOLAR ?



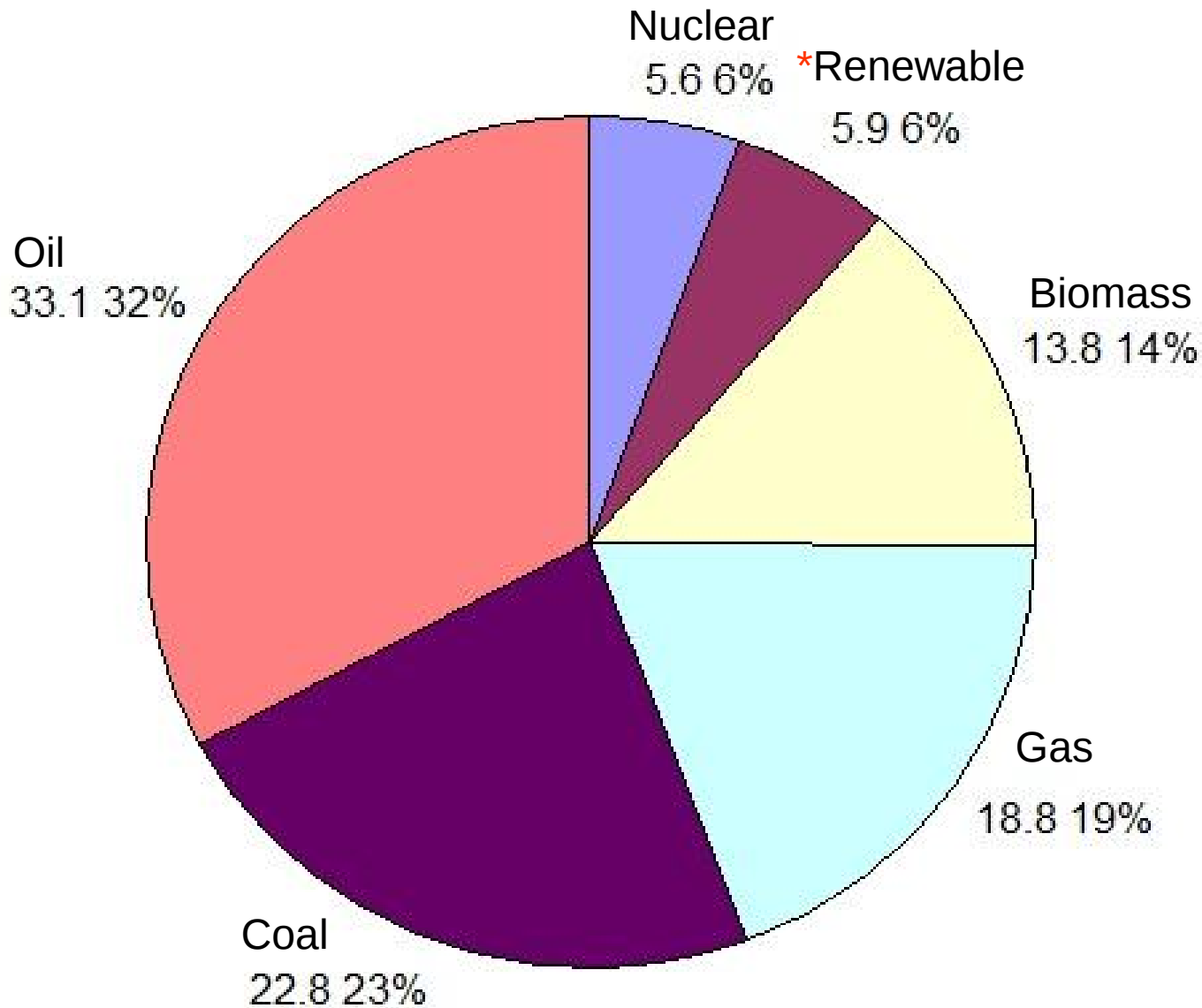
**OUR RESPONSIBILITIES – TO PROTECT THE EARTH FOR FUTURE  
GENERATION**

# **WHY SOLAR ? WHY NOW ?**

-  **GLOBAL WARMING**
-  **ENERGY INDEPENDENCE**
-  **ENERGY SECURITY**
-  **ELECTRICITY PRICES ↑**
-  **GOVERNMENT INITIATIVES / SUPPORT**

# What Energy ?

Global average



and 80% of energy supplies come from limited resources known for environmental pollution !

# Degrading Environment....



Imagine the earth to be a spaceship .

Limited supply of air, water and energy .

All thrash generated carried onboard .

Increase population  $\infty$  energy demand .

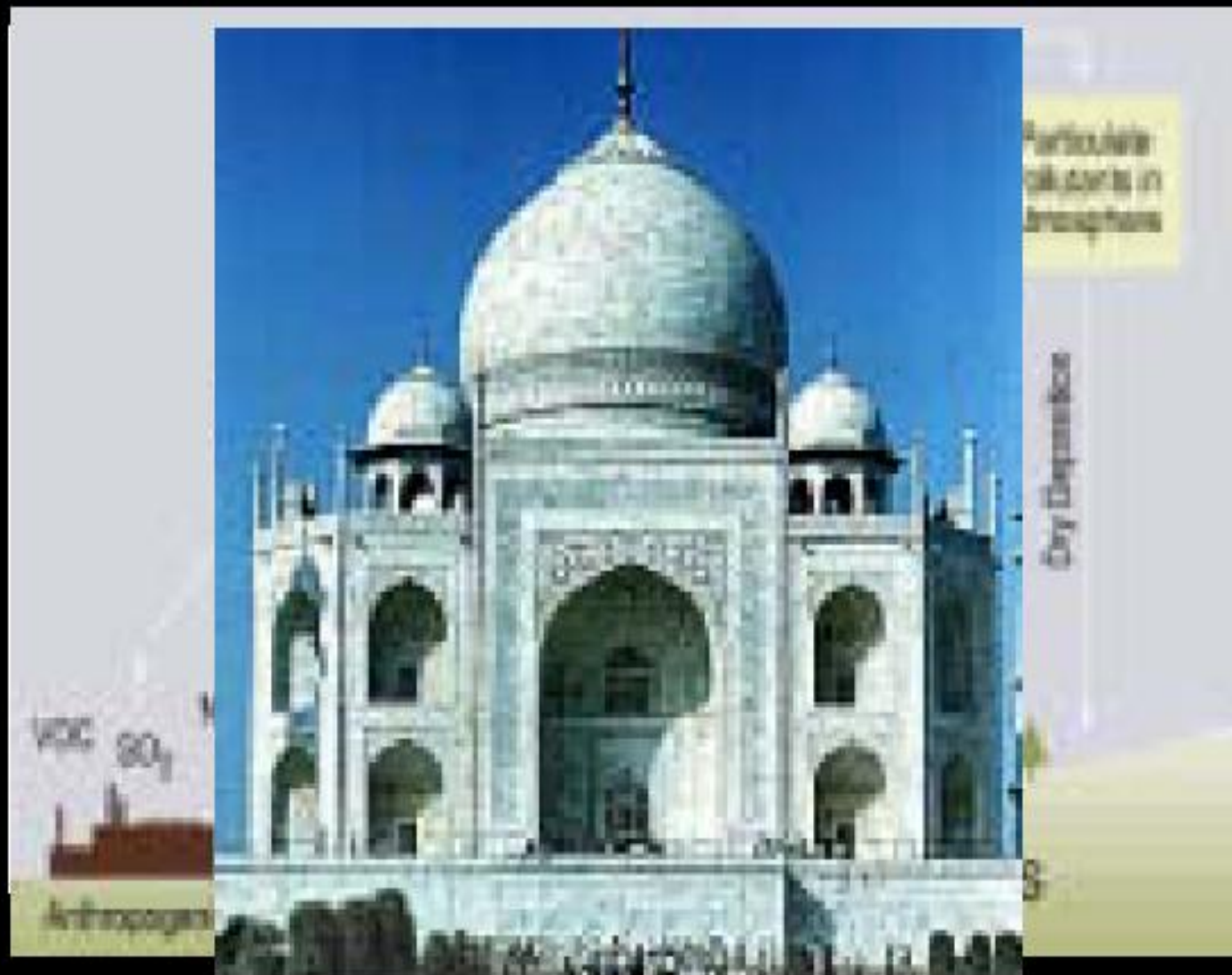


**Non –renewable resources** to last 100 yrs.  
But long before that the pollution caused by  
use of fossil fuels will have caused a **serious  
problem** .

# **THE BURNING OF FOSSIL FUELS IS HAVING A LARGE IMPACT**

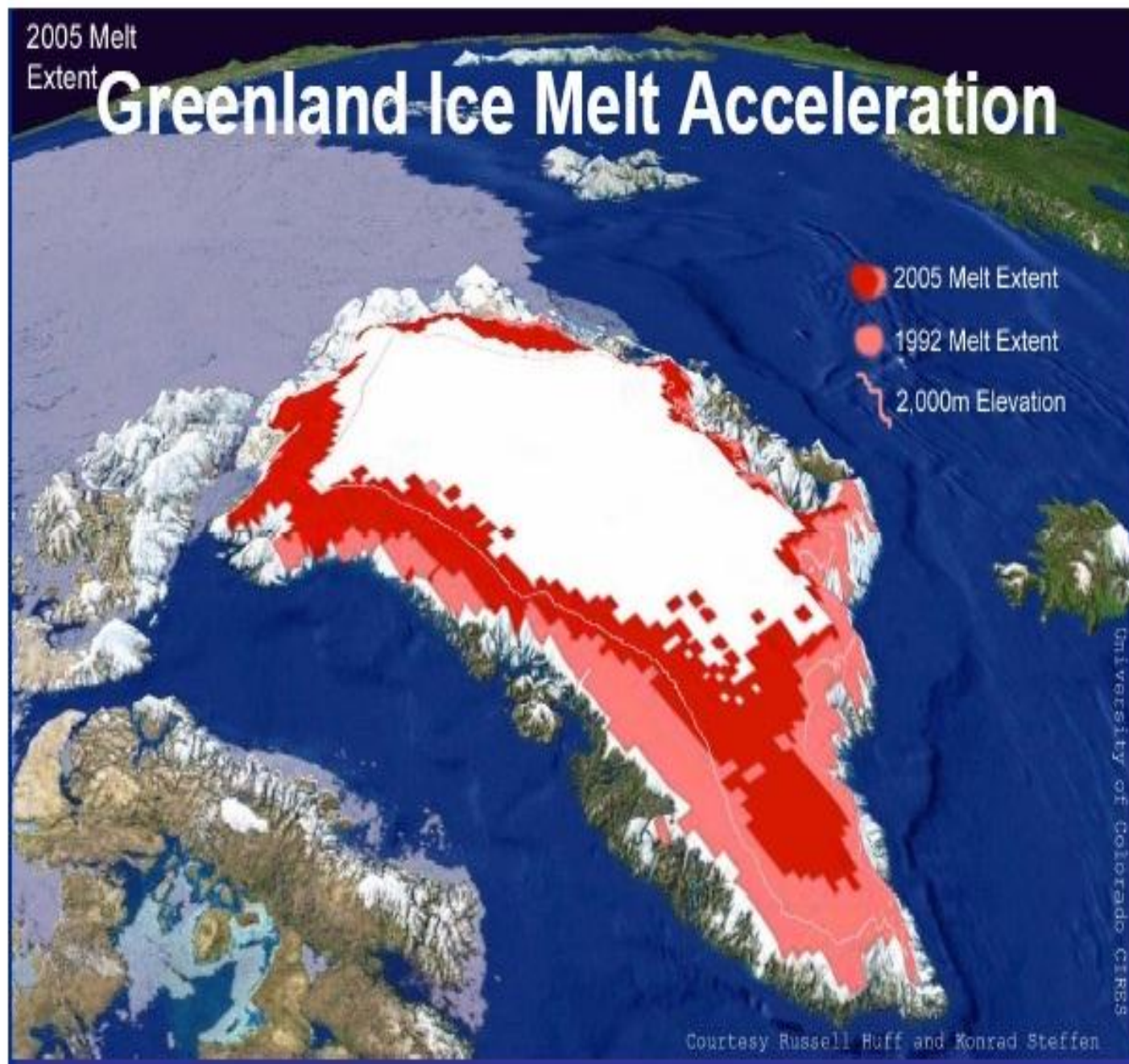


# Environmental Impact ...



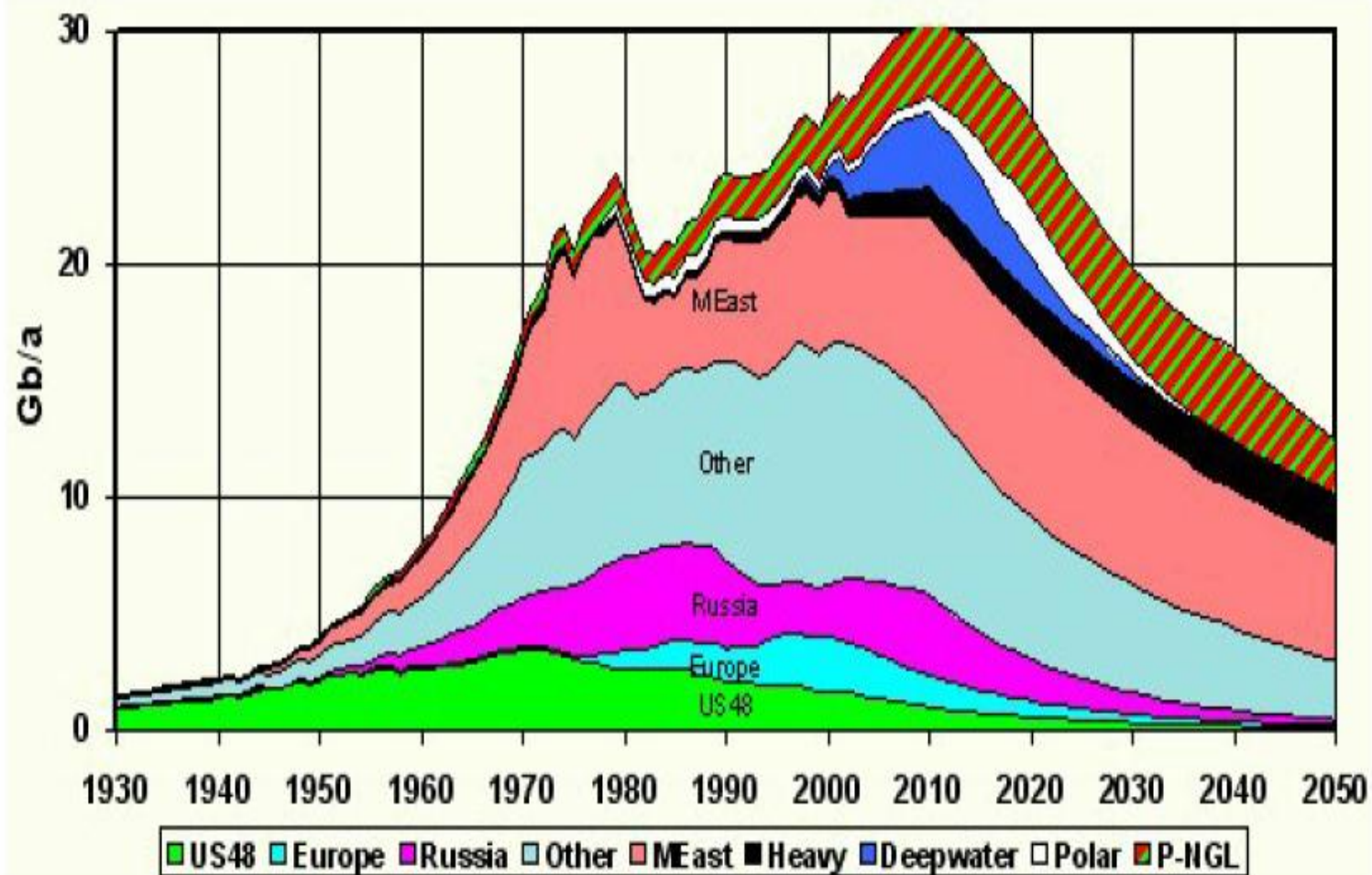
2005 Melt  
Extent

# Greenland Ice Melt Acceleration



# End of an Era

100 years of exponential growth in fossil fuel use will soon be ending due to environmental and economic constraints



# WHY SOLAR ?



You assume the diameter of the earth is 8000 miles and using 2240lb/ton(British ton ), the 4lbs . Can be calculated using the following formula:

$$\frac{4 \times 10^6 \times \pi \times (8 \times 10^3)^2}{4 \times \pi \times (93 \times 10^6)^2 \times 4} = 4.14 \text{ lbs.}$$

*For every kWh of electricity generated by solar energy ,the following emissions are avoided since that kWh need not be generated from a fossil fuel power plant. In one year ,the approximate avoided emissions in lbs/year are :*

| SOLAR POWER PLANT SIZE | Co <sub>2</sub> | NO <sub>x</sub> | SO <sub>x</sub> | PARTICULATE S |
|------------------------|-----------------|-----------------|-----------------|---------------|
| 1kW                    | 2,508           | 6.3             | 5.2             | 0.36          |
| 10kW                   | 25,800          | 63              | 52              | 3.6           |
| 100kW                  | 258,000         | 630             | 520             | 36            |
| 1MW                    | 2,580,000       | 6300            | 6200            | 360           |

**Every second 657 million tons of hydrogen are converted to 653 million tons of helium in our sun . The missing 4 million tons are converted to light and heat energy via \Einstein's E=MC<sup>2</sup> equation and Radiated into space .At an average distance of 93 million miles from the sun ,the earth collects approximately 4lbs.of total energy ,which supports life On earth as we know it .**

## WHY SOLAR ?

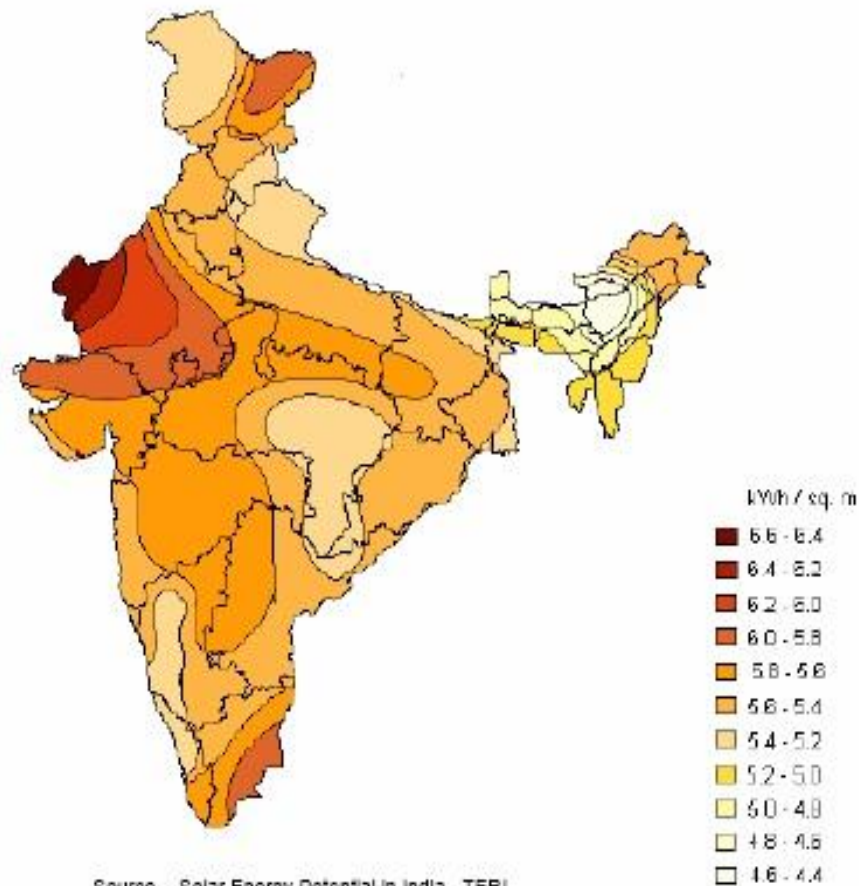
- >> In a single one hour period, the sun sends enough energy to our planet to meet all of our energy needs for an entire year.
- >> The availability and cost of delivering energy from the sun to our planet has remained amazingly constant for 4 billion years.

# India offers huge solar market potential

## Solar Radiation in India

- India receives 3000 hrs\* of sunshine every year , equivalent to 5000 trillion KWH.
- Most parts in India receive 4 – 7 KWh of solar radiation per sq.meter per day with 250 - 300 sunny days in a year.

•<http://www.solarindiaonline.com>;  
The Energy and Resources Institute  
(TERI)



Source - Solar Energy Potential in India - TERI

" We will pool all our scientific, technical and managerial talents, with financial sources, to develop solar energy as a source of abundant energy to power our economy and to transform the lives of our people"  
**– Dr.Manmohan Singh, Prime Minister of India.**

# LAUNCHING OF **SOLAR INDIA**

## JAWAHARLAL NEHRU NATIONAL SOLAR MISSION

THE  HINDU

Manmohan Singh launches 'Solar India'

- 20GW BY 2020
- 100GW BY 2030
- 200GW BY 2050
- 20 MILLION SQ.METER SOLAR THERMAL COLLECTORS (20GW power)
- 20 MILLION SOLAR LIGHTS

*Calls for creation of 'solar valleys' on the lines of the Silicon Valley*



Prime Minister Manmohan Singh with Minister of New and Renewable Energy Farooq Abdullah at the Solar Energy Conclave 2010, in New Delhi on Monday.

# Introducing **SOLAR** power ...

**The Sun is a massive energy source of:**



*(Heat)*

**Solar THERMAL SYSTEMS**



*(Light)*

**Solar PHOTO-VOLTAIC**

# SOLAR THERMAL APPLICATIONS ( PAST )

➤ People have been trying to harness the power of the sun for centuries.

➤ In 1877, air blowing over sun-heated iron was used to heat homes.

➤ In 1910, The first patent involving a solar collector was awarded.

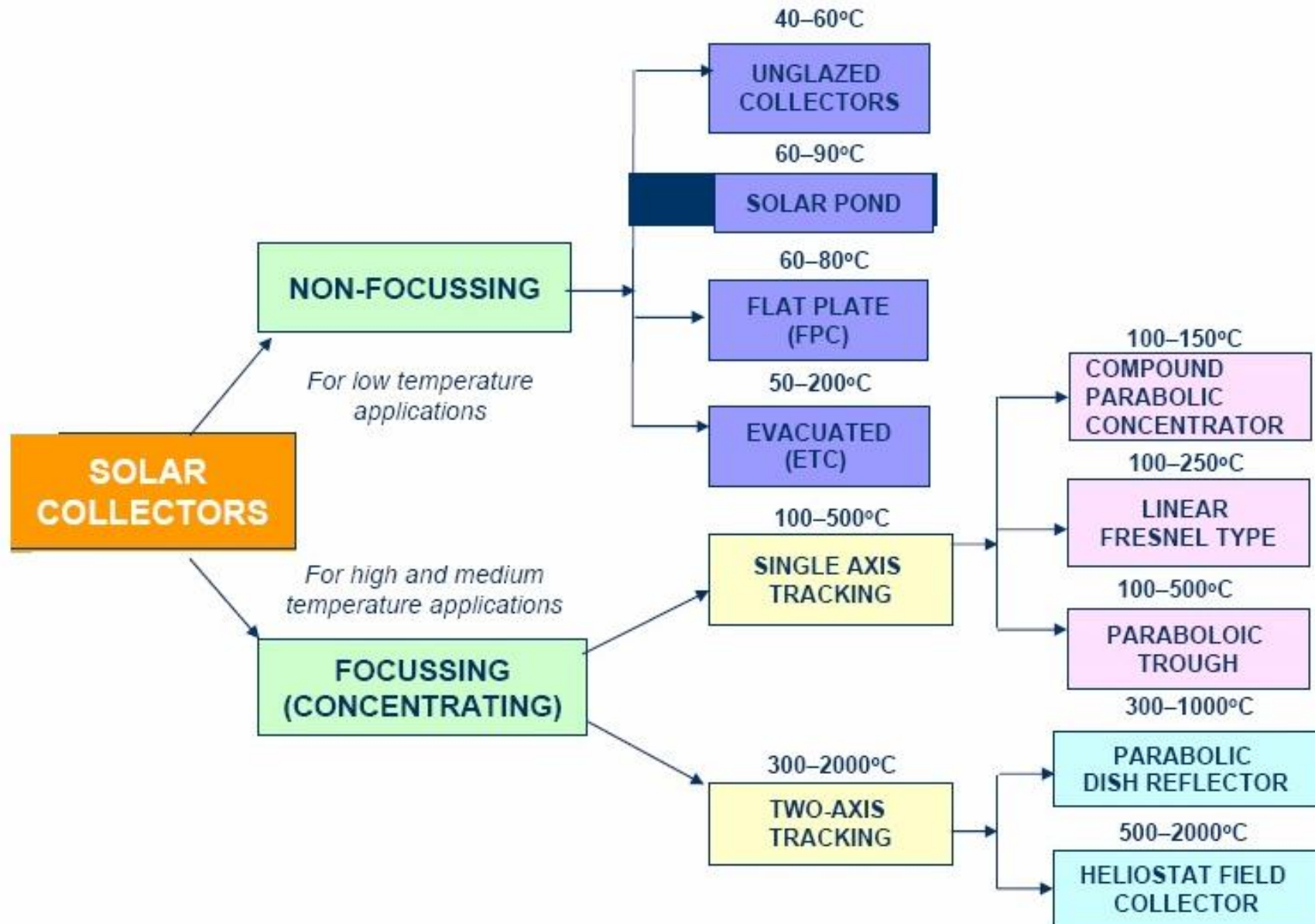
➤ The 1930's saw the first widespread use of solar power for heating.



## Solar Thermal Applications (present)

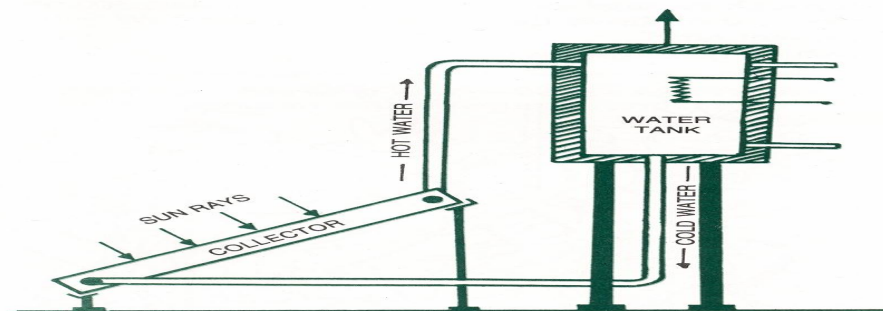
| <b>Thermal Conversion range</b>                                | <b>Applications</b>                                                                                                                                              |
|----------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Low Temperature (20°C-80°C)</b><br><b>NALSUN</b>            | <b>Swimming pool heating</b><br><b>Domestic hot water heating</b><br><b>House heating</b><br><b>Crop Drying</b><br><b>Water Distillation</b>                     |
| <b>Medium Temperature (80°C-200°C)</b><br><b>NALSUN</b>        | <b>Rankine cycle refrigeration</b><br><b>Absorption air conditioning</b><br><b>Industrial drying</b><br><b>Industrial processes</b><br><b>Small power engine</b> |
| <b>High Temperature (&gt;200°C)</b> TANDEM<br><b>ABSORBERS</b> | <b>Industrial processes</b><br><b>Solar power plant</b>                                                                                                          |

# SOLAR ENERGY COLLECTORS



# SOLAR THERMAL APPLICATIONS

## SOLAR WATER HEATING



**HEART OF THE SYSTEM – SELECTIVELY COATED ABSORBER**

# **SELECTIVE ABSORBER COATINGS**

- 1. BLACK NICKEL (POOR MOISTURE RESISTANCE )**
- 2. BLACK CHROMIUM. (NANO COMPOSITE OF CHROMIUM AND CHROMIUM OXIDE)**

## **DRAWBACKS OF BLACK CHROMIUM DEPOSITION**

- 1. HIGH CURRENT DENSITY ( $3\text{A/in}^2$ )**
- 2. LOW TEMPERATURE ( $15^\circ\text{C}$ )**
- 3. ORGANIC ADDITIVES (STABILITY?)**

**ADDRESSED THE ABOVE PROBLEMS**  
**DEVELOPMENT OF NALSUN TECHNOLOGY**

# ADVANTAGES OF NALSUN COATING

**High absorbtivity,  $\alpha < 0.95$**

**Low emissivity,  $\varepsilon < 0.15$**

**Long term Thermal stability**

**Room temperature bath**

**Good covering power**

**Simple bath maintenance & control**

**Stability against atmospheric corrosion**

**Cost-effective coating**

**Easy to apply on the required substrate**

**Reproducibility**

**Good resistance against rubbing and handling**

**SUITABLE FOR BATCH PRODUCTION & CONTINUOUS FOIL COATING**

# **NALSUN & ITS SOCIETAL IMPACT**

**TECHNOLOGY TRANSFER – 26 ENTREPRENEURS**

**SMALL MEDIUM AND LARGE SCALE HOT WATER**

**SYSTEMS – INSTALLED. (HOMES , HOSPITALS ,**

**HOTELS, RESORTS, CONVENTION CENTERS ,**

**INDUSTRIAL CANTEENS,HOSTELS ETC )**

**VIRTUAL POWER STATION**

**“A WATT SAVED IS A WATT GENERATED”**



**100lpd - DOMESTIC**



**5000lpd ñISKCON TEMPLE  
BANGALORE**



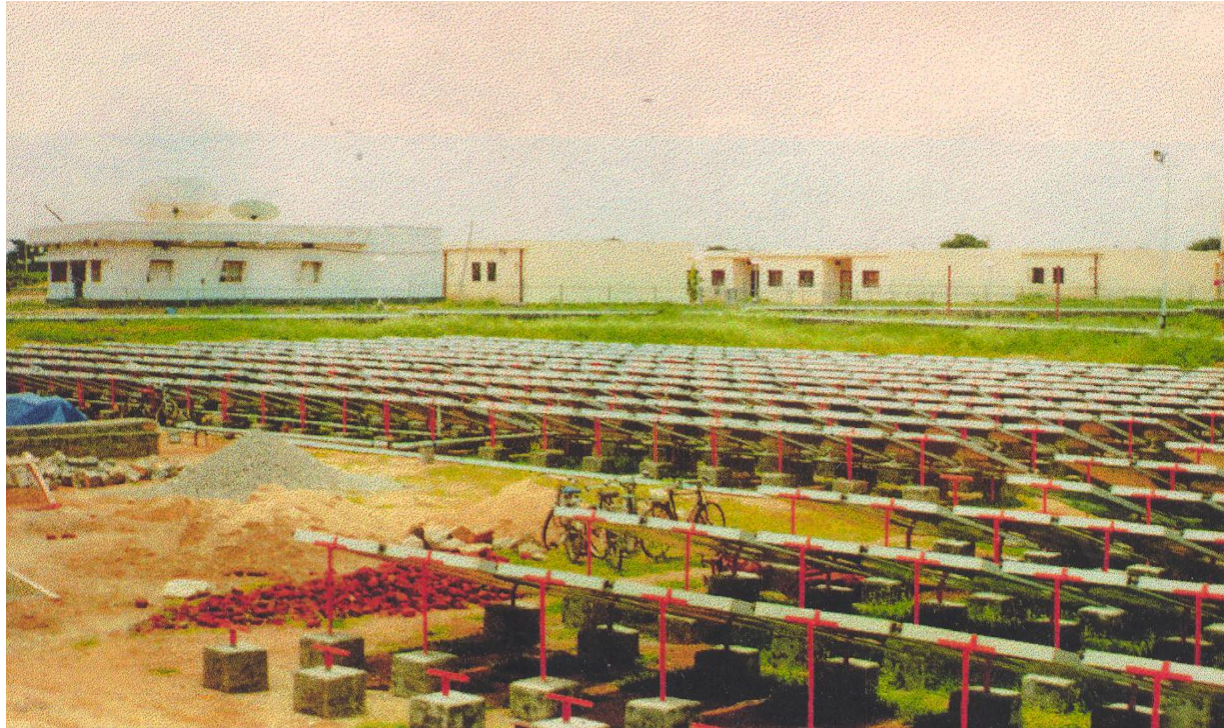
**7000lpd ñTAJ HOTEL**



**3000lpd - DHARAMSHILA  
HOSPITAL**



**50000lpd ñBATRA HOSPITAL  
DELHI**



**PORTION OF THE 1.1LAKH LITERS PER DAY SOLAR WATER  
HEATING SYSTEMS INSTALLED AT M/S SRI VENKATESWARA  
HATCHERIES, VELIJULA, BY M/S SURYODAYA HITECH  
ENGINEERS PVT.LTD., HYDERABAD USING NALSUN  
COATED COLLECTORS**



**PORTION OF THE 1.2 LAKH LITERS PER DAY SOLAR WATER HEATING  
SYSTEMS INSTALLED AT M/S GODAVARI  
FERTILIZERS&CHEMICAL,KAKINADA BY M/S SURYODAYA HITECH  
ENGINEERS PVT.LTD., HYDERABAD USING NALSUN COATED COLLECTORS**

# Solar steam systems



A view of solar steam cooking system installed at Tirupathi, Andhra Pradesh

The system has been designed to generate over 4000 kg. of steam/day at  $180^{\circ}\text{C}$  and  $10\text{ kg/cm}^2$  which is sufficient to cook two meals for around 15,000 persons.



**SOLAR STEAM GENERATION USING NALSUN  
(K G INDUSTRIES COAIMBATORE )**



## Renewable energy at a glance in India



| S.No.      | Source/system                                                      | Estimated potential                       | Achievement as on 31 August 2008           |
|------------|--------------------------------------------------------------------|-------------------------------------------|--------------------------------------------|
| <b>I</b>   | <b>Power from renewables</b>                                       |                                           |                                            |
| <b>A</b>   | <b>Grid-interactive renewable power</b>                            | (MW)                                      | (MW)                                       |
| 1          | Wind power                                                         | 45 195                                    | 9041.80                                    |
| 2          | Bio power (agro residues and plantations)                          | 16 881                                    | 648.60                                     |
| 3          | Bagasse cogeneration                                               | 5 000                                     | 972.83                                     |
| 4          | Small hydro power (up to 25 MW)                                    | 15 000                                    | 2211.14                                    |
| 5          | Energy recovery from waste (MW)                                    | 2 700                                     | 55.75                                      |
| 6          | Solar photovoltaic power                                           | —                                         | 2.12                                       |
|            | <b>Sub total (A)</b>                                               | <b>84 776</b>                             | <b>12 932.24</b>                           |
| <b>B</b>   | <b>Captive/combined heat and power/distributed renewable power</b> |                                           | (MW)                                       |
| 7          | Biomass/cogeneration (non-bagasse)                                 | —                                         | 95.00                                      |
| 8          | Biomass gasifier                                                   | —                                         | 100.11                                     |
| 9          | Energy recovery from waste                                         | —                                         | 26.70                                      |
|            | <b>Sub total (B)</b>                                               | —                                         | <b>221.81</b>                              |
|            | <b>Total (A+B)</b>                                                 | —                                         | <b>13 154.05</b>                           |
| <b>II</b>  | <b>Remote village electrification</b>                              | —                                         | 4 198 villages/hamlets                     |
| <b>III</b> | <b>Decentralized energy systems</b>                                |                                           |                                            |
| 10         | Family-type biogas plants                                          | 120 lakh                                  | 39.94 lakh                                 |
| 11         | Solar photovoltaic systems                                         | 50 MW/km <sup>2</sup>                     | 120 MWp                                    |
|            | i. Solar street lighting system                                    | —                                         | 70 474 nos                                 |
|            | ii. Home lighting system                                           | —                                         | 402 938 nos                                |
|            | iii. Solar lantern                                                 | —                                         | 670 059 nos                                |
|            | iv. Solar power plants                                             | —                                         | 2.22 MW                                    |
|            | v. Solar photovoltaic pumps                                        | —                                         | 7148 nos                                   |
| 12         | Solar thermal systems                                              |                                           |                                            |
|            | i. Solar water heating systems                                     | 140 million m <sup>2</sup> collector area | 2.30 million m <sup>2</sup> collector area |
|            | ii. Solar cookers                                                  | —                                         | 6.20 lakh                                  |
| 13         | Wind pumps                                                         | —                                         | 1284 nos                                   |
| 14         | Aero generator/hybrid systems                                      | —                                         | 675.27 kW                                  |
| <b>IV</b>  | <b>Awareness programmes</b>                                        |                                           |                                            |
| 16         | Energy parks                                                       | —                                         | 504 nos                                    |
| 17         | Akshay Urja shops                                                  | —                                         | 269 nos                                    |
| 21         | Renewable energy clubs                                             | —                                         | 521 nos                                    |
| 22         | District Advisory Committees                                       | —                                         | 560 nos                                    |

MW – megawatt; kW – kilowatt; MW<sub>p</sub> – megawatt peak; m<sup>2</sup> – square metre; km<sup>2</sup> – kilometre square

# COMMERCIALLY SUCCESSFUL –

## 26 ENTREPRENEURS

SOLAR WATER

HEATING

| Potential                          | Achievement                     |
|------------------------------------|---------------------------------|
| 1400 Lakhs sq.m.<br>collector area | 23 lakhs sq.m<br>collector area |

ENERGY

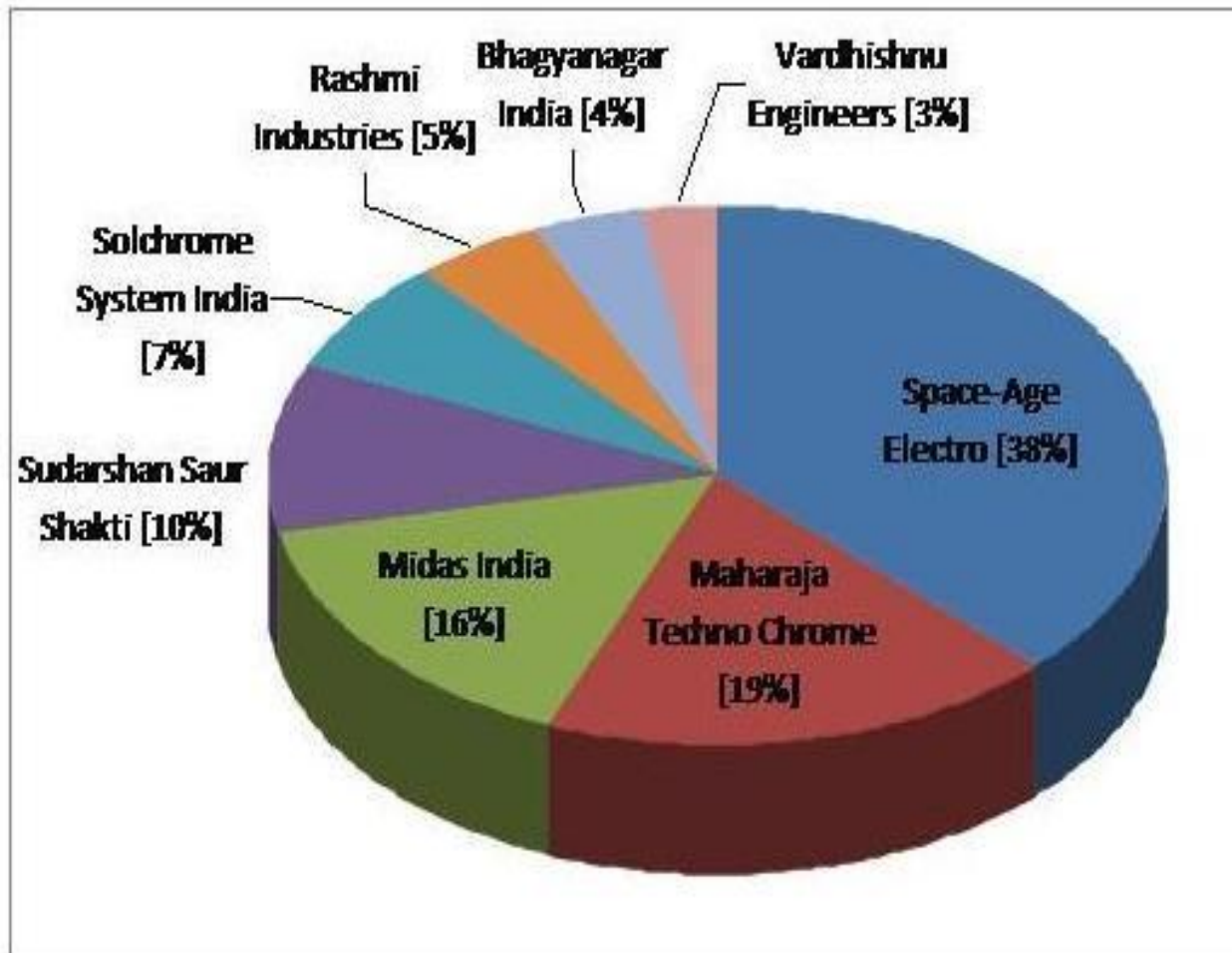
SAVINGS

| Collector area | Energy Savings |
|----------------|----------------|
| ≈ 1000 sq.m    | 1 MW           |
| 23 lakhs sq.m  | 2300MW         |

MARKET UTILIZATION – NALSUN COATINGS – 90%

## Absorber Coating: a Rising Industry in India

Submitted by **Baerbel Epp** on Wed, 07/08/2009 - 12:50.



India's coating industry has shown impressive growth rates over the last ten years. Just one manufacturer of selective coating dominated the industry a decade ago: Solchrome, who had obtained the technology from Canada. Today, 8 manufacturers are using the Nalsun technology developed by the NAL.

**Jaideep Malaviya**



11<sup>th</sup> May  
**Technology Day** 2010



**Shri Prithviraj Chavan**  
Hon'ble Union Minister of State (I/C)  
for Science & Technology  
and Earth Sciences

**Congratulations**  
to the scientists and technologists  
of the country for their exemplary contributions that have helped  
the nation emerge as a technology superpower and improve the  
quality of lives of a billion.

### Glimpses of Recent Technological Achievements & Initiatives

- Technology Mission: Winning Augmentation and Renovation for Water (WAR for Water) launched to address the problem of water scarcity in the country.
- Low Thermal Desalination Technology for one lakh litre per day and above capacity developed and stabilized.
- Nano Silver Impregnated Ceramic Drinking Water Filter developed.
- Affordable health care products, including a large number of vaccines, cellular therapies, implants and devices, and diagnostics developed and introduced.
- Nutritional foods and food supplements propagated on massive scale, including Zinc as a treatment for childhood diarrhea.
- A mega project, "Technology and Products for Solar Energy Utilization through Networking (TAP-SUN)", a



Solar Collectors lined up at one of the TAP-SUN coastal installation

CSIR led Team-India consortium, launched in partnership with MNRE.

- 24x7 Solar Thermal Biomass Hybrid Demonstration Power Plant for Rural Electrification, ready for commercialisation.
- Oil Zapper – An eco-friendly technology developed for remediation of oily sludge and oil spills.
- Standard modulus carbon fibre technology commercialised – A 400 TPA plant using CSIR-NAL technology established.
- Fully indigenous Detonation Spray Coating (DSC) Technology commercialised.
- Several new species of ornamental high value fish ready for commercial production.



Parabolic Trough



Carbon Fibre Precision Winding Unit



DSC Unit in operation



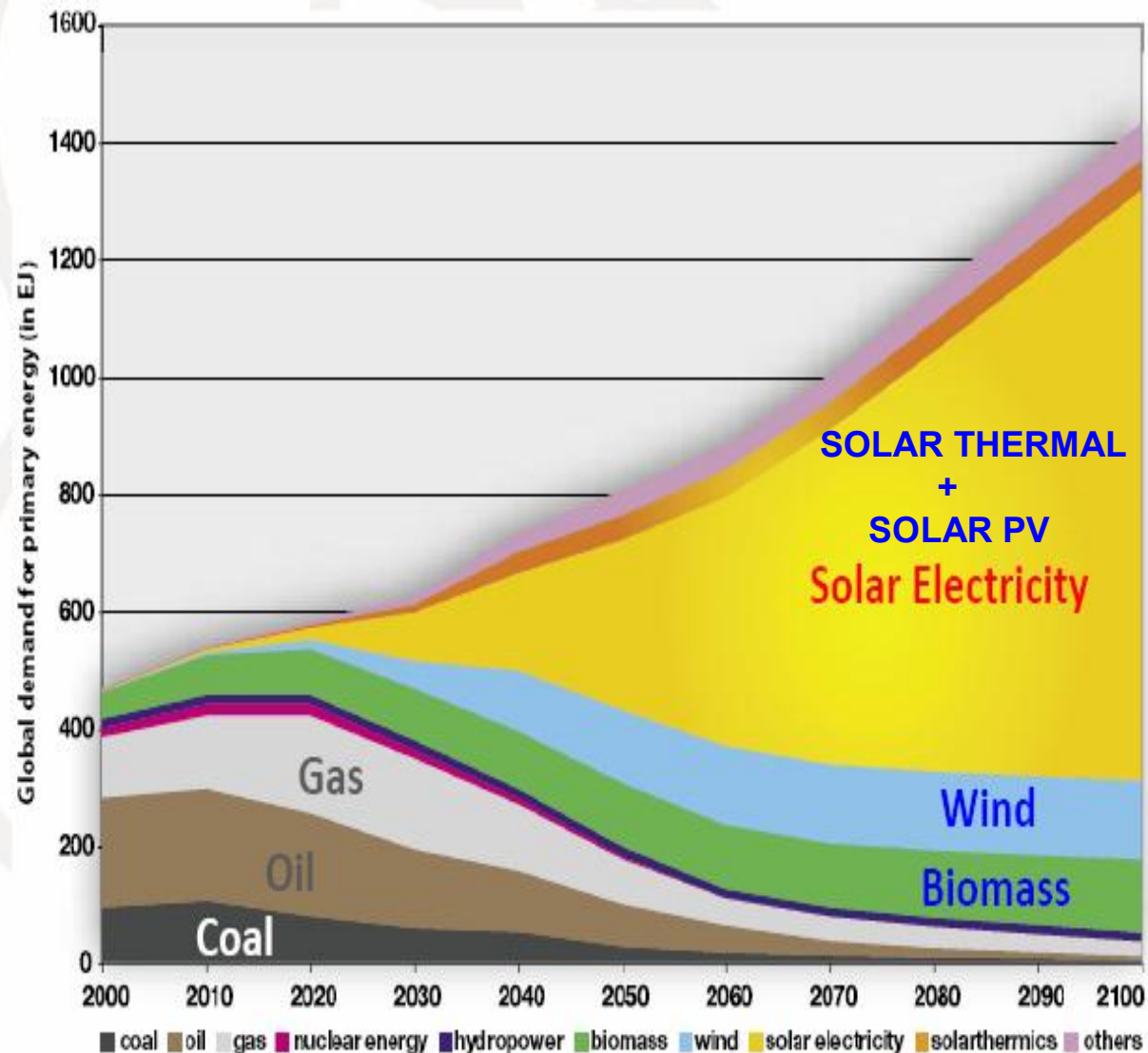
Ornamental Fish Culture

- CSIR awarded for the highest number of Indian patents granted (528 nos) by DIPP, Government of India.
- Special Public-Private Partnership schemes launched, including:
  - Small Business Innovation Research Initiative (SBIRI)
  - Biotechnology Industry Partnership Programme (BIPP)
  - Biotechnology Industry Research & Development Assistance Programme (BIRAP)
- To further encourage R&D across all sectors of the economy, weighted deduction on expenditure incurred on approved in-house R&D units enhanced from 150 per cent to 200 per cent.
- A national effort led by CSIR has helped government to give nod for researchers to have an equity stake in scientific enterprises and spin-offs while still being employed in their organisations.



**Ministry of Science and Technology  
and Ministry of Earth Sciences**  
Government of India

# Global Demand of Primary Energy



Source : the European renewable energy council

## Keeping the Lights On - 2007



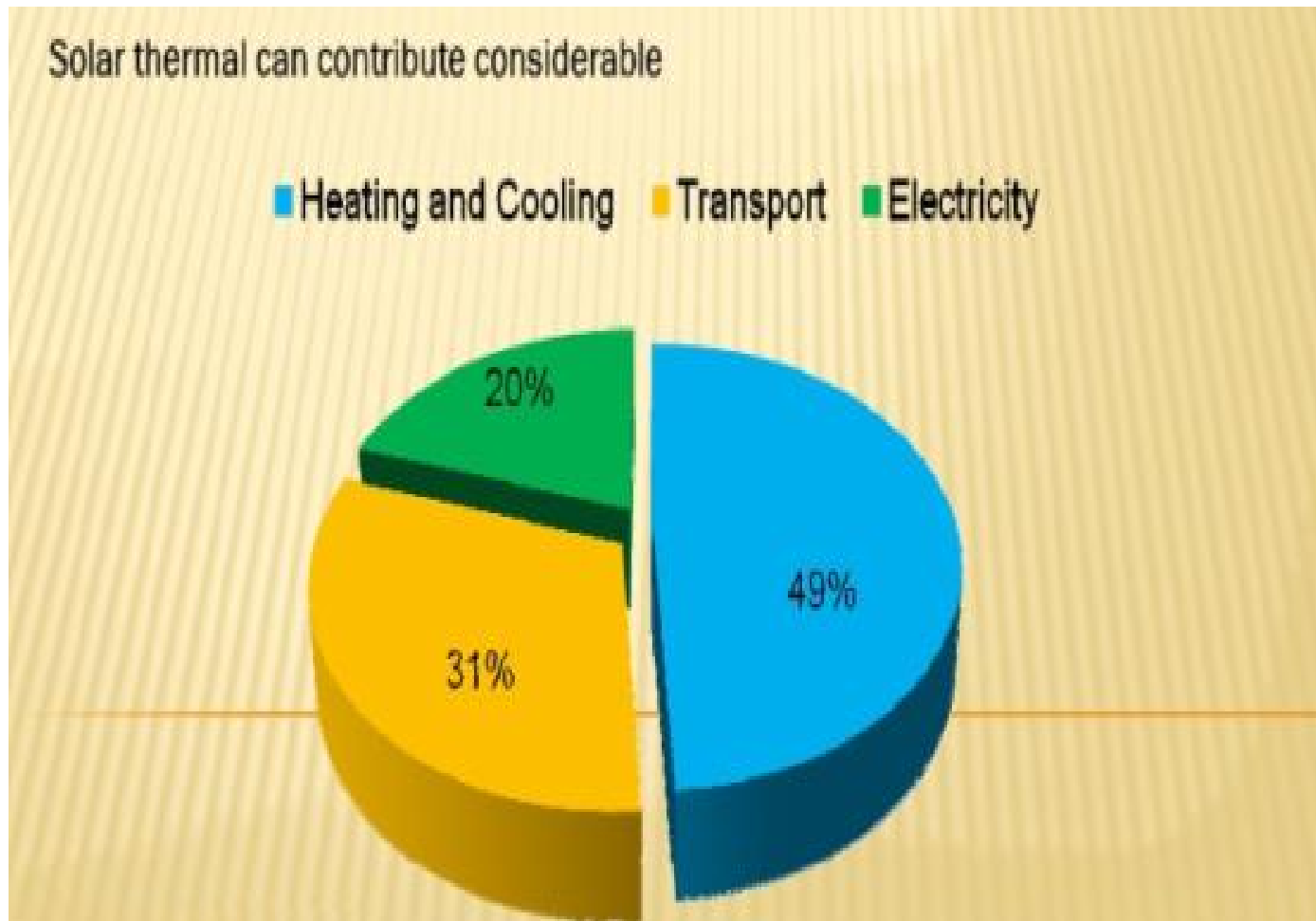
Source GE Solar

# Keeping the Lights On - 2030



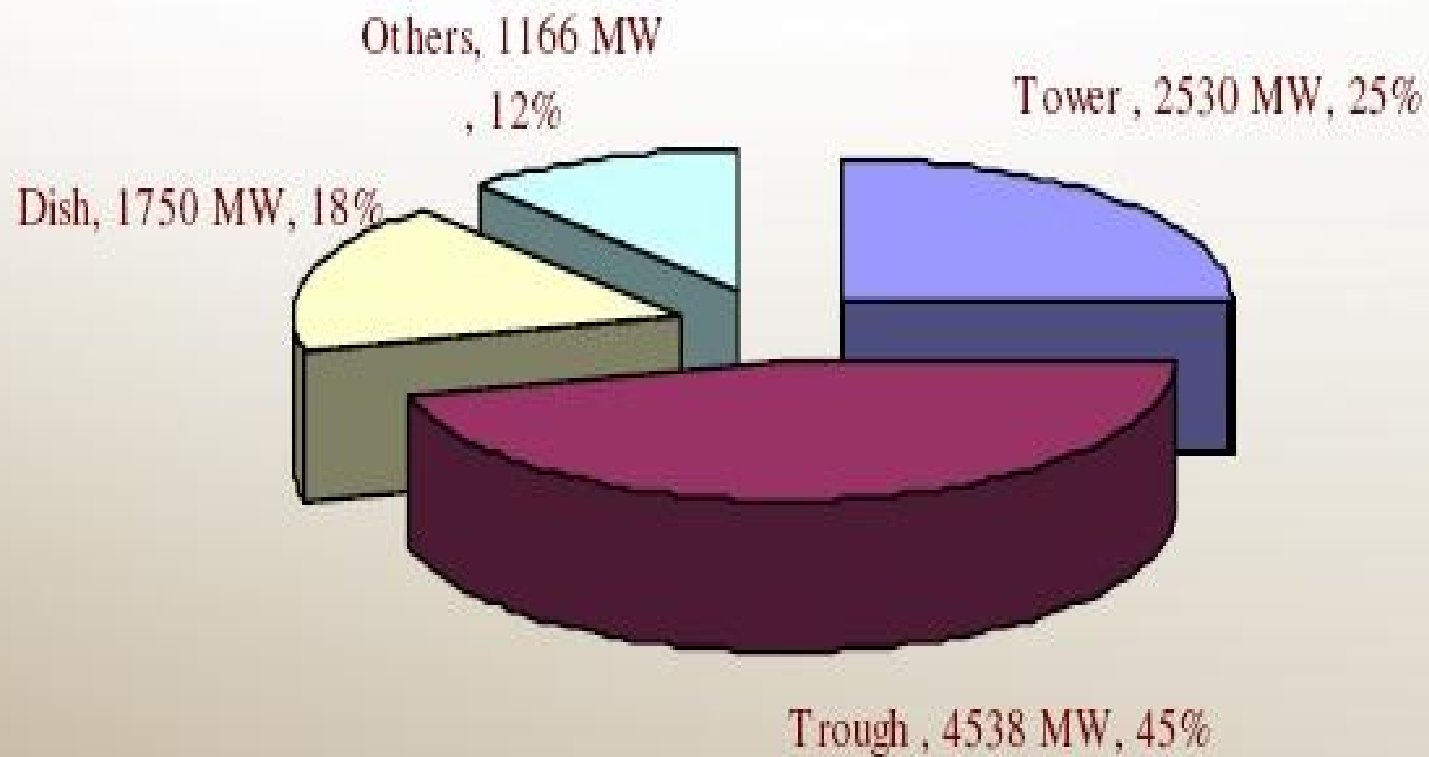
Source GE Solar

# SOLAR THERMAL POWER (FUTURE)



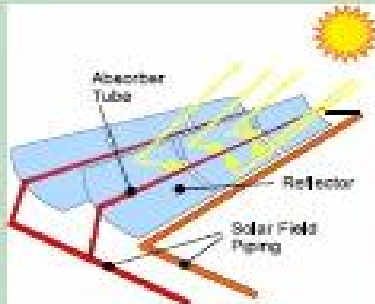
## Global Trends

### Future Projects-By Technology

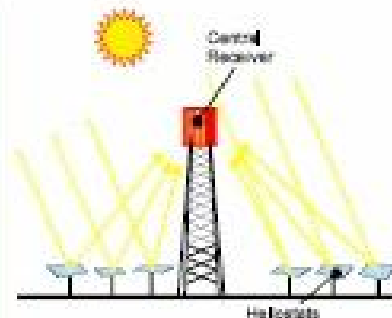


# THE TECHNOLOGY

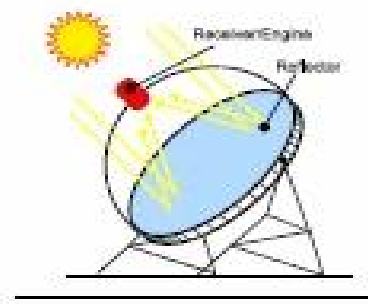
## VARIOUS TYPES OF SOLAR THERMAL (CSP ) TECHNOLOGY



Trough



Tower



Dish



Fresnel



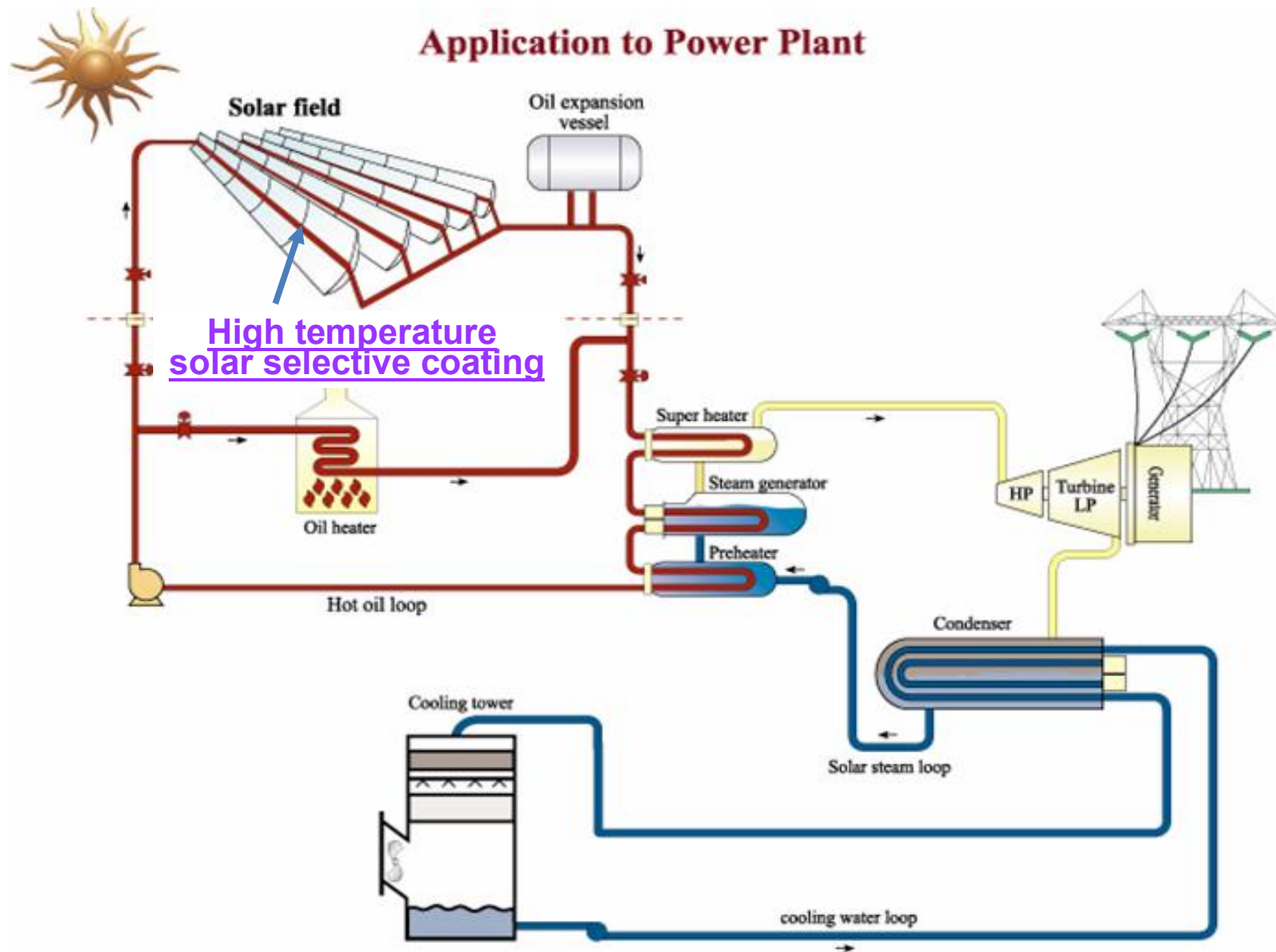
- 20 + years of operational experience worldwide
- 400+MW installed
- Established global supply chain
- Molten salt, or hot oil storage
- Indirect steam generation

- Array of individually tracking mirrors
- Less land requirement
- Small scale demo plants operating
- Molten salt storage capability
- Higher operating temp

- Distributed systems possible
- Higher temperature
- Higher cost
- Not proven at scale
- Limited storage capability
- Suitable for off-grid generation

- Lower efficiency
- Lower cost
- Unproven tech

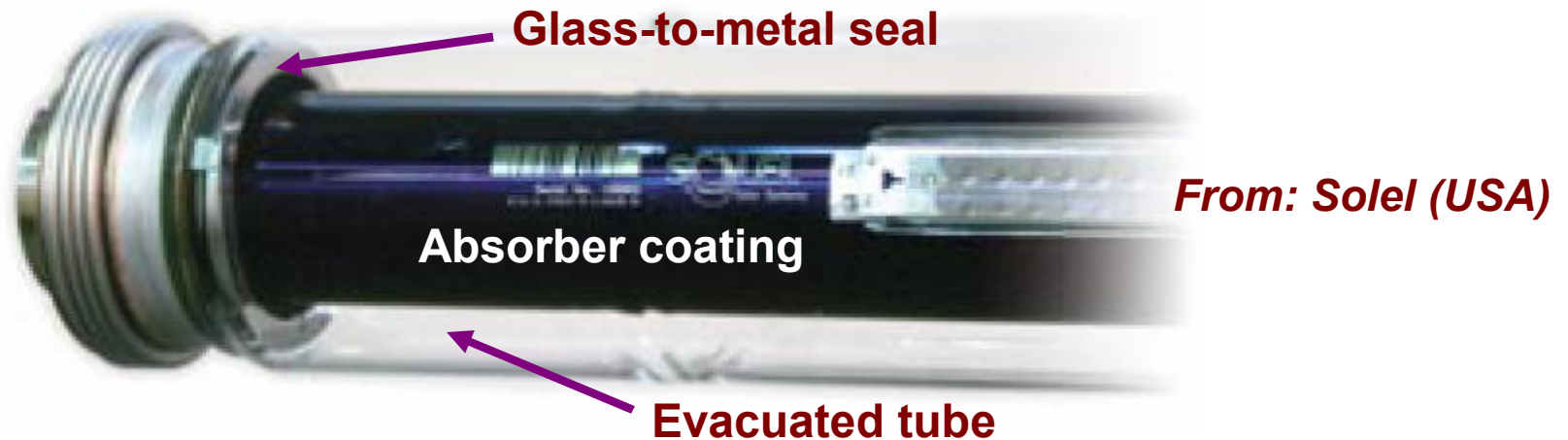
# Parabolic Trough Technology for Solar Power Generation



*From: Solel (USA)*

## Salient Features of Absorber Tubes

- Typically, a long SS tube with solar selective coating surrounded by evacuated glass tube
- Glass-to-metal seal to achieve vacuum and metal bellows to heat exchanger
- Vacuum =  $10^{-4}$  Torr



### Challenges:

- Glass-to-metal seal failures due to insufficient protection
- Hydrogen release related failures
- Sputtering on large tubes – **Large investment & infrastructure**

**No Indigenous Efforts on Sputter Deposited Solar Absorber Tubes**

# Need for Newer Solar Absorbers for Power Generation

## Concentrating Solar Power (CSP) Technologies

- Private industries such as Space Age, Maharaja Techno Group, KG Industries, many more and BARC approached NAL for sputter deposited high temperature solar selective coatings



Parabolic Trough



Solar Power Tower



Parabolic Dish

High Temperature Stable Solar Absorber Coatings ( $>400^{\circ}\text{C}$ )

## Basic Requirements of a High Temperature Solar Absorber

- High solar absorptance (**>0.90**)
- Low thermal emittance (**<0.05, e.g., on Cu**) : **Radiative losses  $\propto T^4$**
- High thermal stability (**>400°C**)
- Long-term stability at higher operating temperatures
- High corrosion resistance

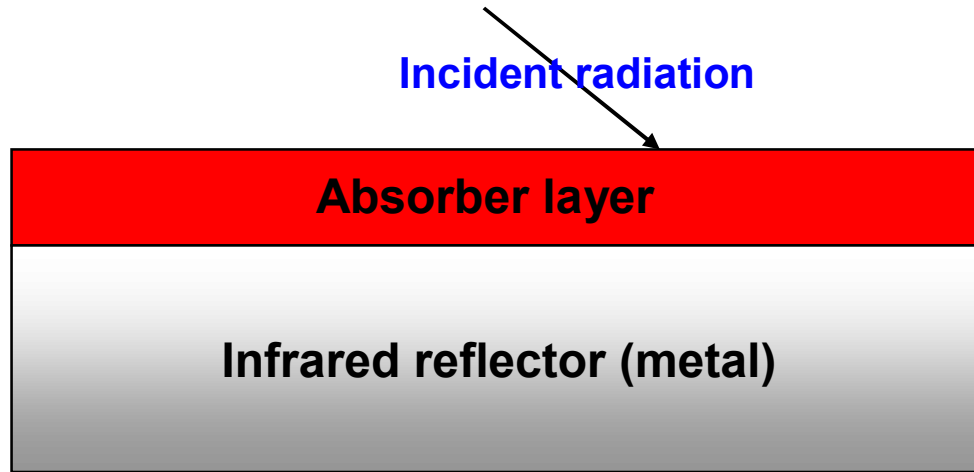
## Important Cermet based High-Temperature Solar Selective Coatings

| Coating                           | $\alpha/\varepsilon$ | Thermal Stability       |
|-----------------------------------|----------------------|-------------------------|
| Ni-Al <sub>2</sub> O <sub>3</sub> | 0.94/0.06            | 500°C in air            |
| Pt-Al <sub>2</sub> O <sub>3</sub> | 0.92/0.14            | 600°C in H <sub>2</sub> |
| Mo-Al <sub>2</sub> O <sub>3</sub> | 0.96/0.16            | 500°C in vacuum         |
| W-Al <sub>2</sub> O <sub>3</sub>  | 0.93/0.024           | -                       |
| W-SiO <sub>2</sub>                | 0.916/0.027          | -                       |
| W-AlN                             | 0.93/0.10            | 500°C in vacuum         |
| SS-AlN                            | 0.95/0.13            | 500°C in vacuum         |

 **Australian patent**

**Long Term Thermal Stability Not Known in Public Domain**

# ABSORBER-REFLECTOR TANDEM



**It is a combination of two materials, one highly absorbing in the visible region and the other highly reflecting in the infrared.**

# NAL Initiatives on High Temperature Solar Selective Coatings (Sputter Deposited Nanostructured Tandem Absorbers)

## Motivation

- Technology for high temp. SSC not available in the Country

## Novelty

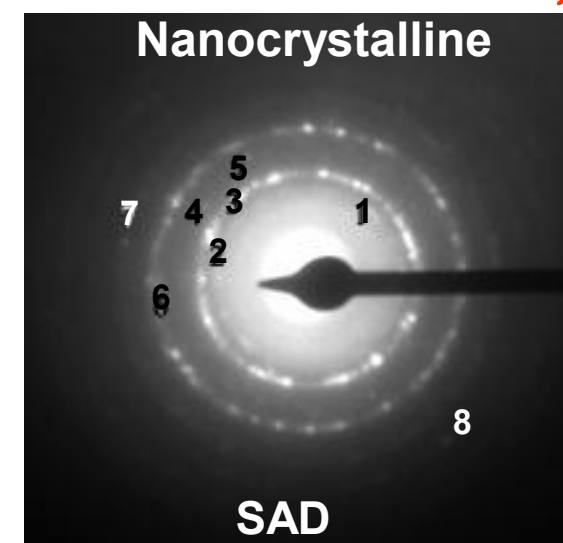
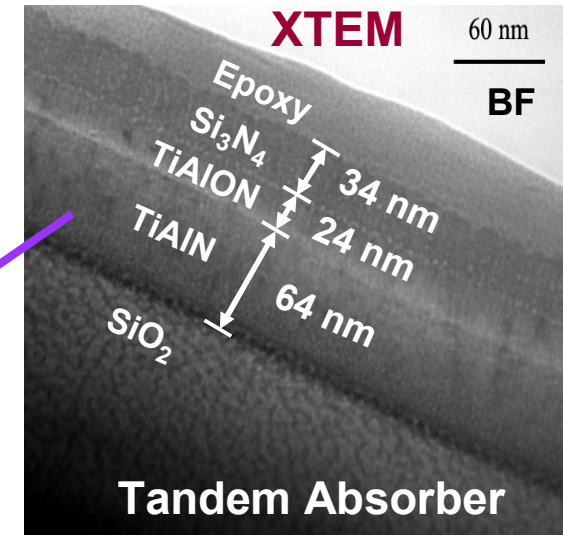
- Transition metal nitrides and oxy-nitrides
- Compositional stability at high temp.
- **FIRST OF ITS KIND**

**~120 nm Thickness**

| Coating                                          | $\alpha/\epsilon$ | Stability in air |
|--------------------------------------------------|-------------------|------------------|
| <b>*TiAlN/TiAlON/Si<sub>3</sub>N<sub>4</sub></b> | <b>0.95/0.07</b>  | <b>550°C</b>     |
| TiAlN/CrAlON/Si <sub>3</sub> N <sub>4</sub>      | 0.95/0.07         | 450°C            |
| NbAlN/NbAlON/Si <sub>3</sub> N <sub>4</sub>      | 0.95/0.06         | 500°C            |
| TiAlN/AlON                                       | 0.94/0.06         | 550°C            |

**\*Ideal Coating for Solar Power Generation**

**Patent filed in India, Germany & Australia - 2006**

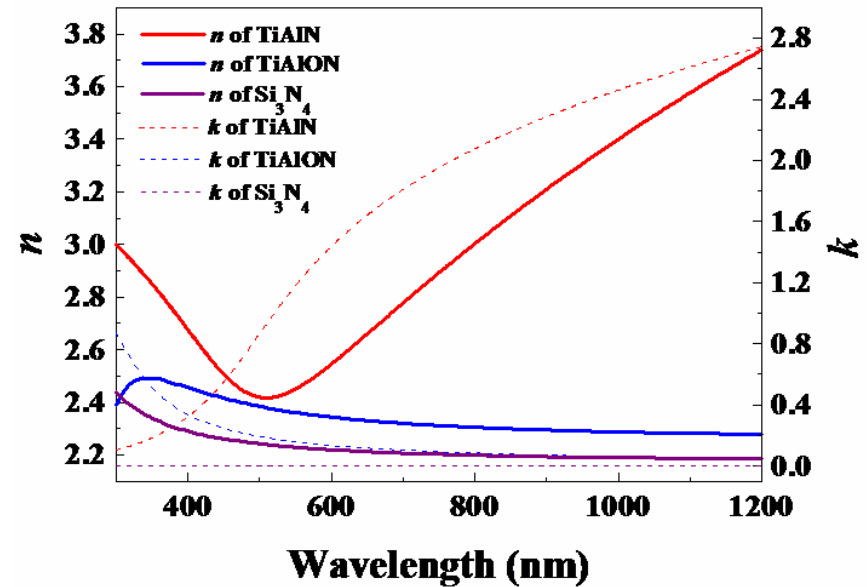
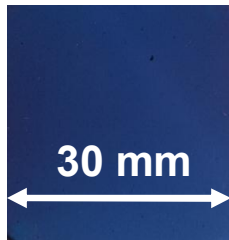


Barshilia et al. App. Phys. Lett. 89 (2006)191909

# Laboratory Scale Sputter Deposited Solar Selective Coatings

## Long Term Thermal Stability in Air...

- Stable up to 525°C for 50 hrs  
450°C for 150 hrs  
350°C for 225 hrs
- Stability in vacuum: 750°C for 2 hrs
- No phase transformation up to 800°C



- Graded refractive indices
- TiAlN as the main absorber layer

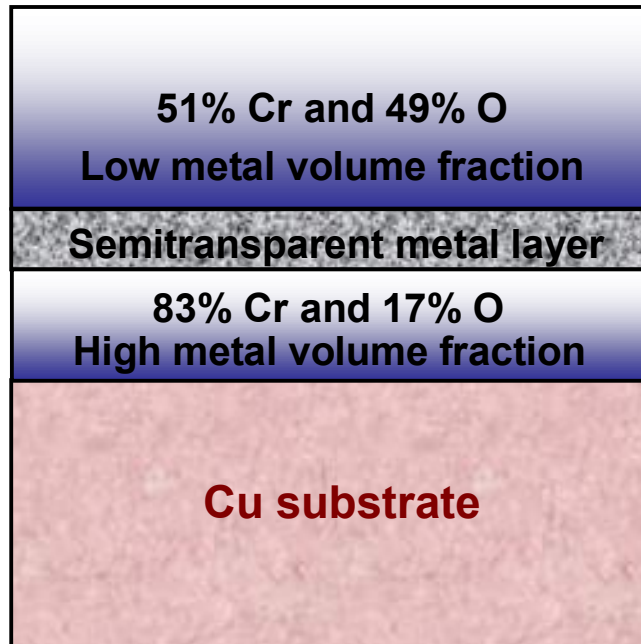
## Why?

- TiAlN acts as a diffusion barrier for metal
- Interdiffusion between TiAlN/TiAlON and TiAlON/Si<sub>3</sub>N<sub>4</sub> is very low up to 600°C
- TiAlN, TiAlON and Si<sub>3</sub>N<sub>4</sub> exhibit very high oxidation resistance: 750, 900 & 1400°C



Magnetron Sputtering System

## Other Initiatives - Multilayer Absorbers & Nanocermets for Low- and Mid-Temperature Applications

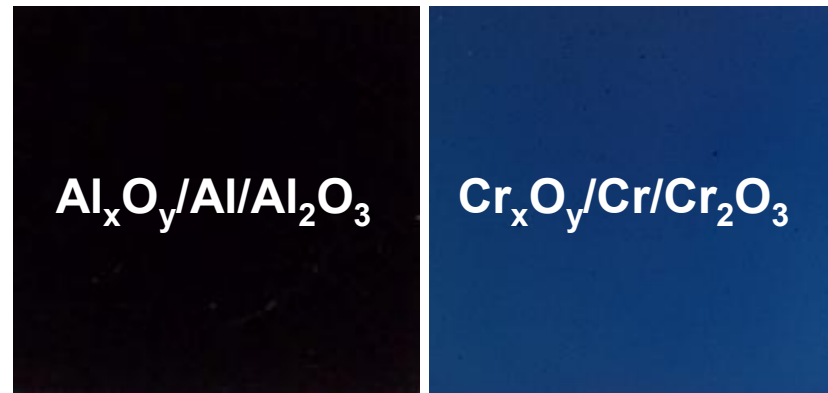


$\text{Cr}_2\text{O}_3$  (64 nm)

Cr (13 nm)

$\text{Cr}_2\text{O}_3$  (28 nm)

| Coating                                                   | $\alpha/\varepsilon$ | Stability |
|-----------------------------------------------------------|----------------------|-----------|
| $\text{Cr}_x\text{O}_y/\text{Cr}/\text{Cr}_2\text{O}_3$   | 0.91/0.06            | 325°C     |
| * $\text{Al}_x\text{O}_y/\text{Al}/\text{Al}_2\text{O}_3$ | 0.97/0.06            | 350°C     |
| $\text{HfO}_x/\text{Hf}/\text{HfO}_2$                     | 0.92/0.05            | 400°C     |
| $\text{Ag}/\text{Al}_2\text{O}_3$                         | 0.92/0.05            | 300°C     |



### Salient Features:

- $\alpha/\varepsilon = 0.91/0.06$
- Stable up to 325°C in air for 2 hrs and 250°C for 250 hrs
- Coating process can be scaled up for domestic hot water applications

**\*Green Technology : Potential Candidate for Replacement for Black Chrome**

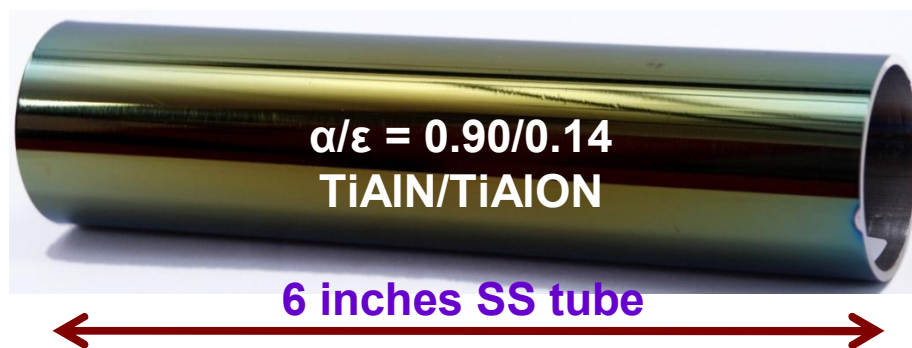
# Scaling Up of The Laboratory Process for the Deposition of Nanostructured Solar Selective Coatings on 6" Long Tubes



## Novelty

- A dry, clean and green process for manufacture of solar selective coating
- New coating combination
- High solar selectivity
- High thermal stability
- Long service life at higher operating temperature (*Theoretical*)

## Magnetron



Supported by MNRE, New Delhi

# **PATENTS**

## **NALSUN I**

**V.K.William Grips, Indira Rajagopal and S.R. Rajagopalan**

**Indian Patent No: 167895 (1.11.1991)**

**U.S.A Patent No: 5019223 (28.5.1991)**

**Australian Patent No: 611957 (5.11.1991)**

**European Patent No: 323683 (8.9.1993)**

**Canadian Patent No: 2006130 (12.5.1998)**

## **NALSUN II**

**V.K.William Grips, Indira Rajagopal and S.R. Rajagopalan**

Indian Patent : No. 195681 (21.4.2006)

## **NALSUN III**

**V.K.William Grips, Indira Rajagopal and S.R. Rajagopalan**

Indian Patent : No. 202362 (23.2.2007)

## **TANDOM ABSORBERS**

**Harish barshilia , V.W.Grips , K.S.Rajam**

US Patent #7,585,568 B2 (2009)

The background image is a blurred photograph of a person running through a field of tall grass. A large, bright orange shape, possibly a flag or a piece of clothing, is visible in the background, also blurred. The sky is a pale blue with some light clouds.

you save **energy**

you save **money**

you save the  
**environment**



New challenges

- .
- .
- .

The need to consider a new future

- .
- .
- .

New opportunities

- .
- .
- .

A photograph of a sunset or sunrise over a body of water. The sun is a bright, glowing orb in the upper right quadrant, casting a long, shimmering reflection down the center of the water. The sky is a deep orange, and the water's surface is dark with fine ripples. The text "Thank You" is centered horizontally across the middle of the image in a white, sans-serif font.

Thank You