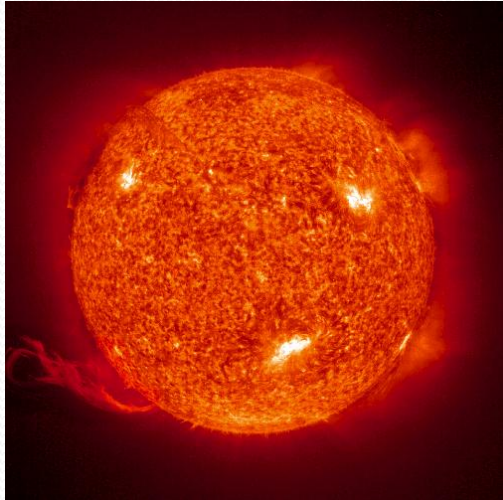


# Deployment of SOLAR ENERGY in India: the last ten years, the next 20 years

**Syamal Gupta**  
Chairman Emeritus, Tata BP Solar  
Chairman, TCE Consulting Engineers Limited

# Potential of solar energy



  
**100,000 x 10<sup>12</sup> Watts**



Present Global consumption:  $15 \times 10^{12}$  Watts

Global consumption in 2050:  $25-35 \times 10^{12}$  Watts

**Solar energy can provide all the energy we need**

**India receives 4-7kWh of solar energy across 300 days/year**

**India can generate  $600 \times 10^{12}$ W,  
thousands of times present consumption**

# Climate change – target limit to 2°C rise

## BBC: May 2009

“About three-quarters of the world's fossil fuel reserves must be left unused if society is to avoid dangerous climate change”

## Reuters: May 2009

“World can burn only 25 % of oil & coal safely”

## Independent: May 2009

“World will have exceeded 2050 safe carbon emissions limit by 2020”

## New Scientist: May 2009

“Humanity's carbon budget set at one trillion tonnes”



May 2009

## Indian Power Scenario

Current Total Installed Capacity: 152,148 MW

Current Five Year Plan (2007-12) : 80,000 MW additional

Investment required (next 5 years): US\$ 120 billion – 150 billion

6<sup>th</sup> largest energy consumer

3<sup>rd</sup> largest Transmission & Distribution

Wide Supply Demand-gap: 9% - 14%

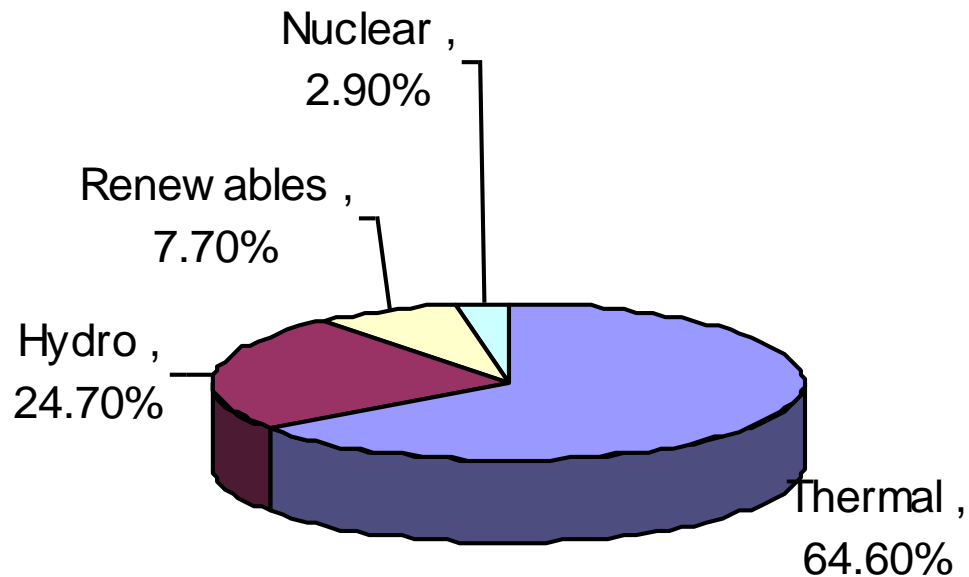
Energy Deficient (612 kWh per capita)

Aggregate Technical & Commercial Losses: 30-45%

No access to electricity for 80,000 villages, 400 million persons

Skewed distribution: Urban India consumes 87% of total supply

## 152,148 MW Total Installed Power Capacity In India



### Solar:

- More than 700,000 PV systems; 55,000 street lighting systems

# India makes headway in climate policy

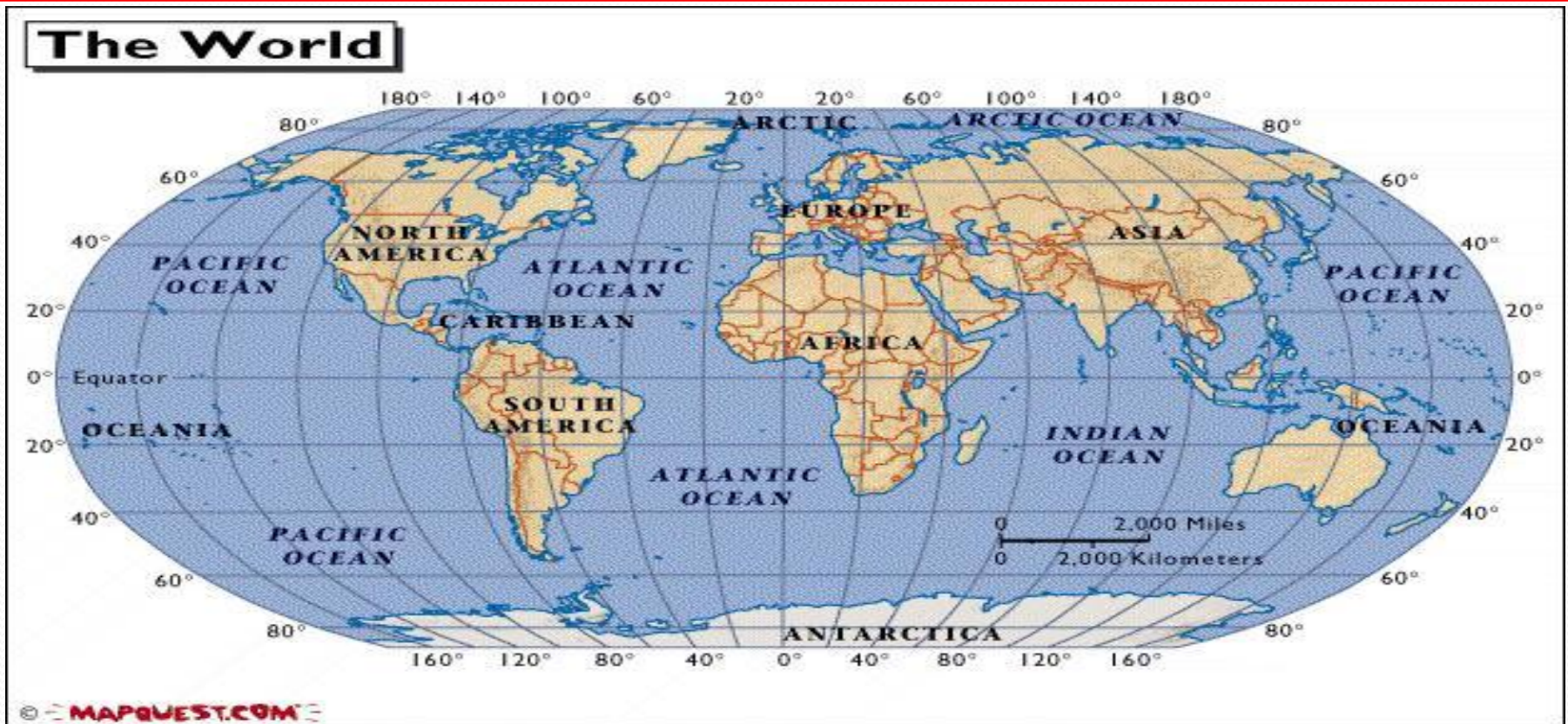
- India to invest **US\$19 billion** by 2050 in Solar Power
  - Current capacity  $5 \times 10^6$ W
  - 2020 planned  $20 \times 10^9$ W
  - 2030 planned  $100 \times 10^9$ W
  - 2050 planned  $200 \times 10^9$ W
  
- By comparison in 2020
  - China plans  $10 \times 10^9$ W
  - Japan plans  $28 \times 10^9$ W

## SOLAR ENERGY - INDIA

Land Resources: 3.1 million sqm; 2.45% of the world

Receives 4 – 7 kWh/sqm/day; Sunny Days: 300 per year

Possibility of 5000 trillion kWh/ year



# NATIONAL SOLAR MISSION

## Jawaharlal Nehru National Solar Mission

To be launched on 14 November 2009, the birth anniversary of Pandit Jawaharlal Nehru, first Prime Minister of independent India

- Target Generation: 20,000 MW by 2020
- 100,000 MW by 2030
- 200,000 MW by 2050

Total Investment required US\$ 19 billion

Achieve: Solar power costs at INR 4-5 (8-10 c) / kWh by 2017-2020

Grid Tariff parity for solar by 2020

Parity with Coal based Thermal power by 2030

Solar manufacturing capacity of 4– 5000 MW by 2017

## Jawaharlal Nehru National Solar Mission (contd)

All new thermal plants to have 5% solar power.  
For every 3000 MW thermal power added every year,  
Addition to solar capacity will be 150 MW/ yr

Vacant land in existing Thermal/ Hydro/ Nuclear power plants  
adds up to 5000 acres of land to generate 800- 1000 MW of solar  
power.

## Jawaharlal Nehru National Solar Mission (contd)

Period up to 2020 divided in three phases:

Phase 1: 2009-2012

Phase 2: 2012 - 2017

Phase 2: 2017- 2020

Aims of First Phase (2009-2012) include:

- rapid scaling-up to drive down costs,
- spurring domestic manufacturing,
- validating technological and economic viability of different solar applications, and
- consolidation of ongoing projects in rural, urban and industrial applications.

## Jawaharlal Nehru National Solar Mission (contd)

The first phase will see:

- rollout of some commercial scale utility plants, which will be mainly PV but some solar thermal plants are not ruled out.
- Solar PV rooftop systems on government/ official buildings will be made compulsory.

Estimated 2000 – 3000 govt/ official buildings of 500 sqm or more which add up to 3 million sqm of space available for rooftop solar. These will be used to generate 100 MW solar power.

The target date of installation of these panels is 2009-2012.

Same can be replicated on the rooftops of commercial and industrial buildings.

## Jawaharlal Nehru National Solar Mission (contd)

Solar Manufacturing & Technology Parks:

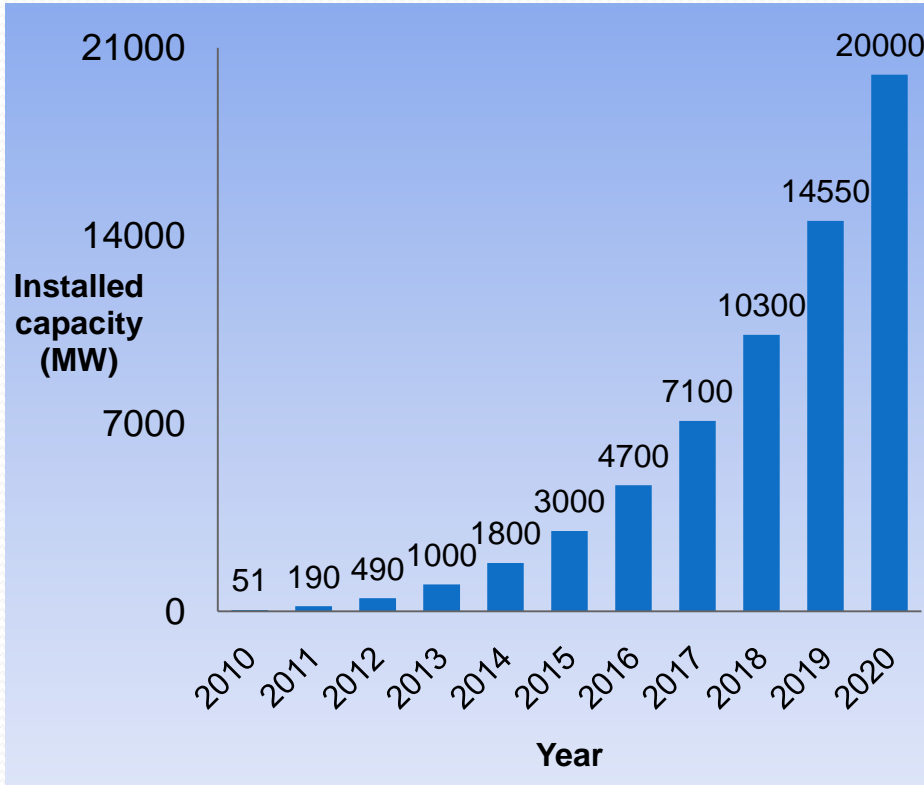
Promotion of local mfg capacity across solar value chain from raw material to components

Target 1 – 1.5 GW by 2012

Solar generation parks for utility scale plants: may be bid out like UMPP

# India's \$19 billion solar initiative

How does India intend to ramp up?



## Revenue from Cess

Fuel	Present annual consumption /capacity	Proposed Cess	Annual revenue from Cess
Coal	300 million tonnes	\$0.5/Tonne	\$240 million
Petrol	10327 KT	\$1/500 Liters	\$28 million
Diesel	42847 KT	\$1/500 Liters	\$100 million
Thermal power	78398 MW	\$1/MWh	\$480 million
			<b>\$848 million</b>

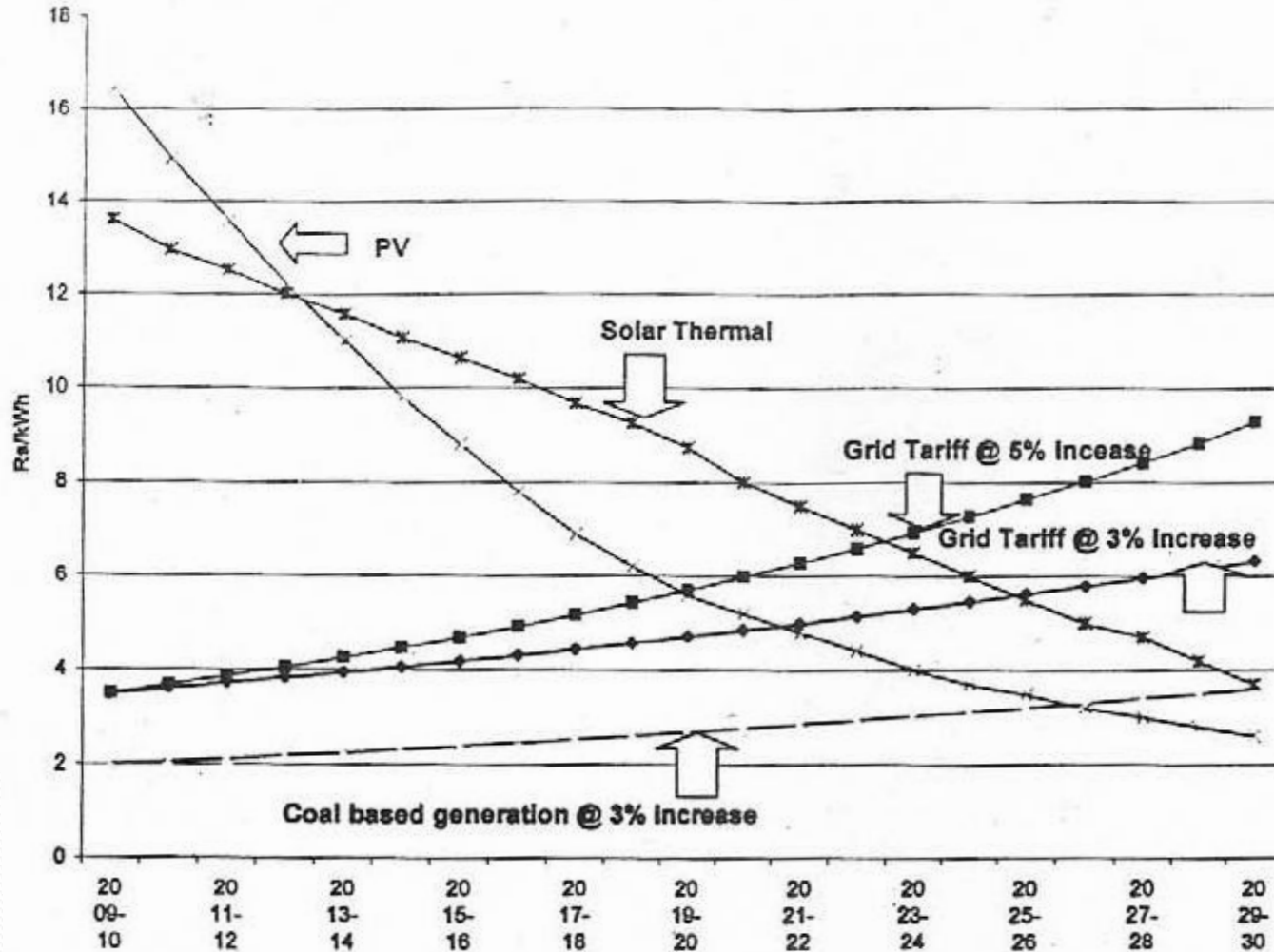
Period	Investment
2008 - 2012	\$1.0 – 1.2 billion
2013 - 2017	\$2.4 – 3.0 billion

# Pathways to 20,000 MW Goal

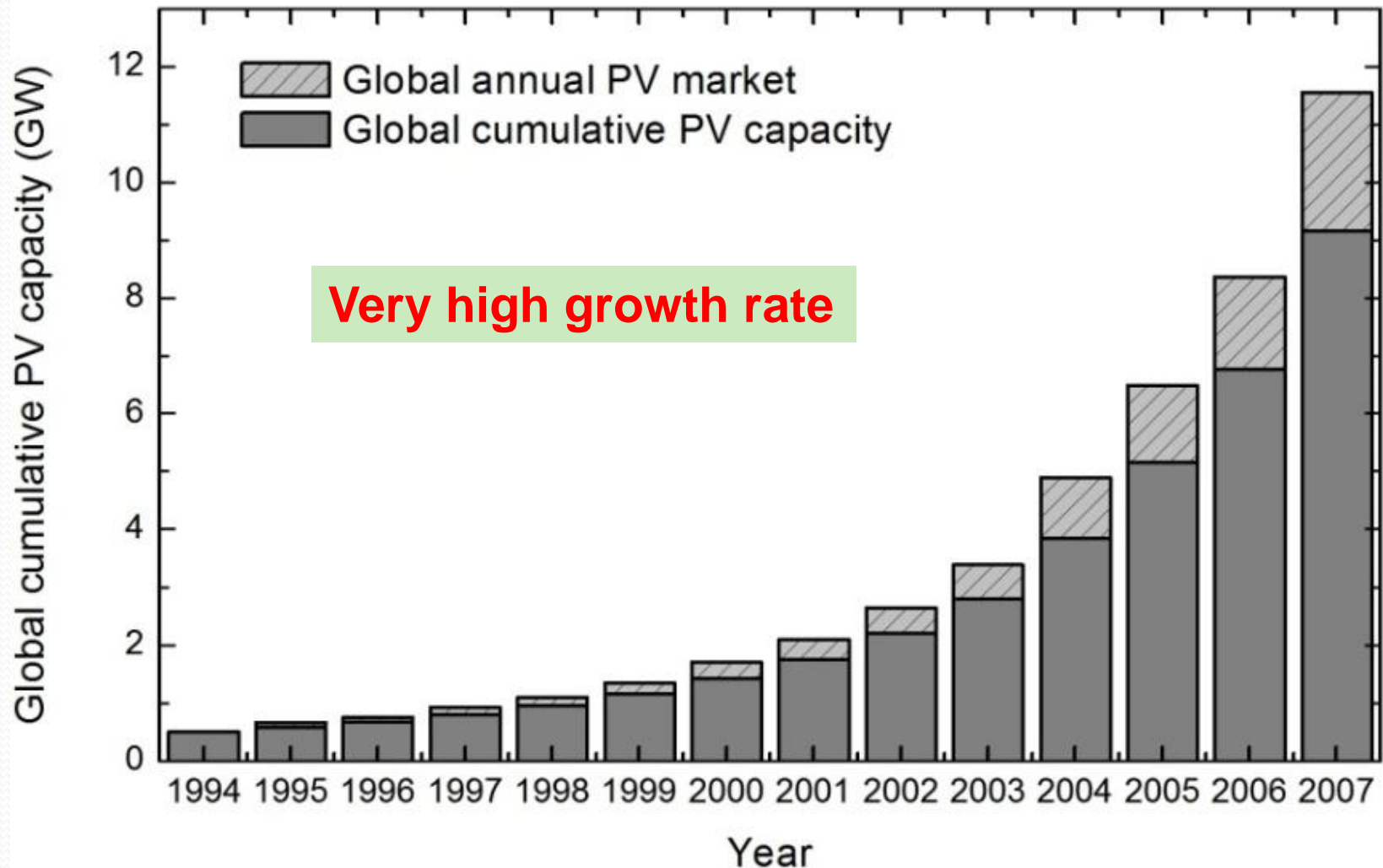
	Incentives
1.	10 yrs no income/sales tax
2.	Zero import duty on capital equipment, raw materials
3.	Excise duty exemption
4.	Low interest rates on manufacturing loans
5.	Incentives under Systematic Investment plants

Installation at Sources	Estimated energy output
<b>Grid power</b>	12000 MW
<b>Rooftop PV</b>	3000 MW 1 million solar roofs @ average 3KW per system
<b>Rural installations (grid + stand-alone)</b>	3000 MW
<b>Other distributed solar PV (e.g. telecom towers)</b>	2000 MW
<b>Solar lighting, heating and other applications</b>	Solar lighting for 20 million households  Solar collector area of 20 million m <sup>2</sup> for heating applications

# Cost Projections and Grid Parity

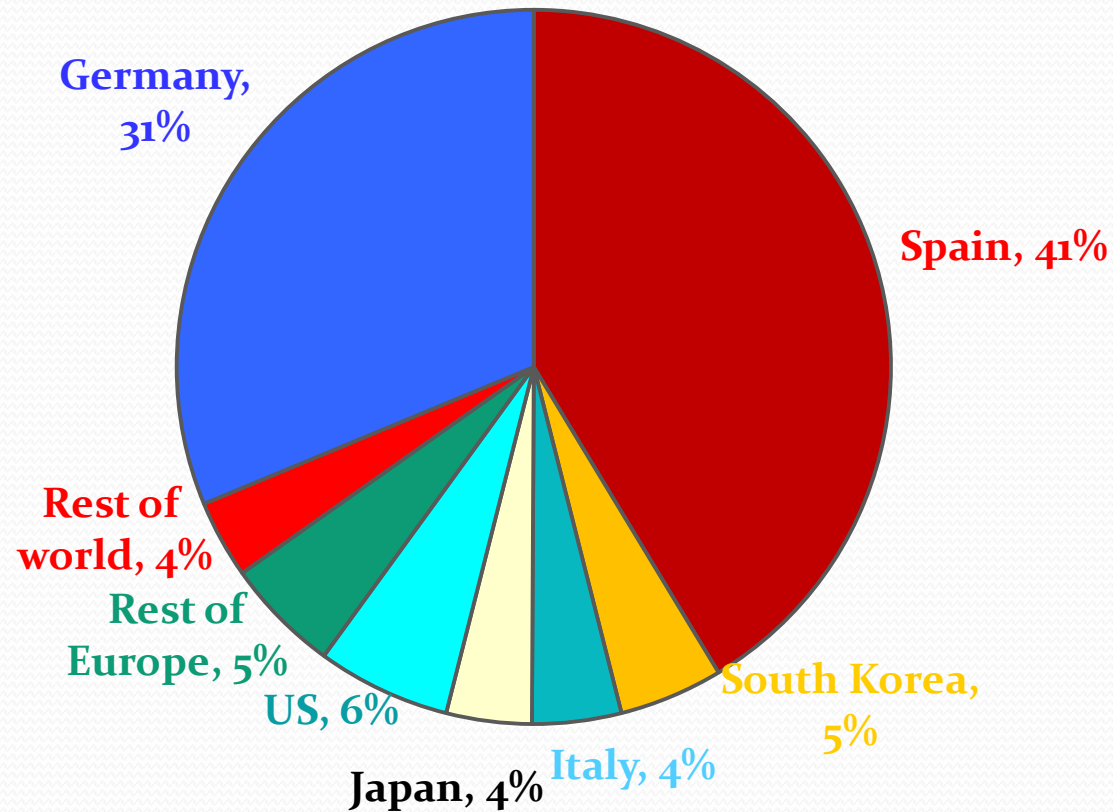


# Global PV market - Growth



# Installed capacities globally

World Photovoltaic market in **2008**,  
Total **5.95 GW**



# PV investments in India

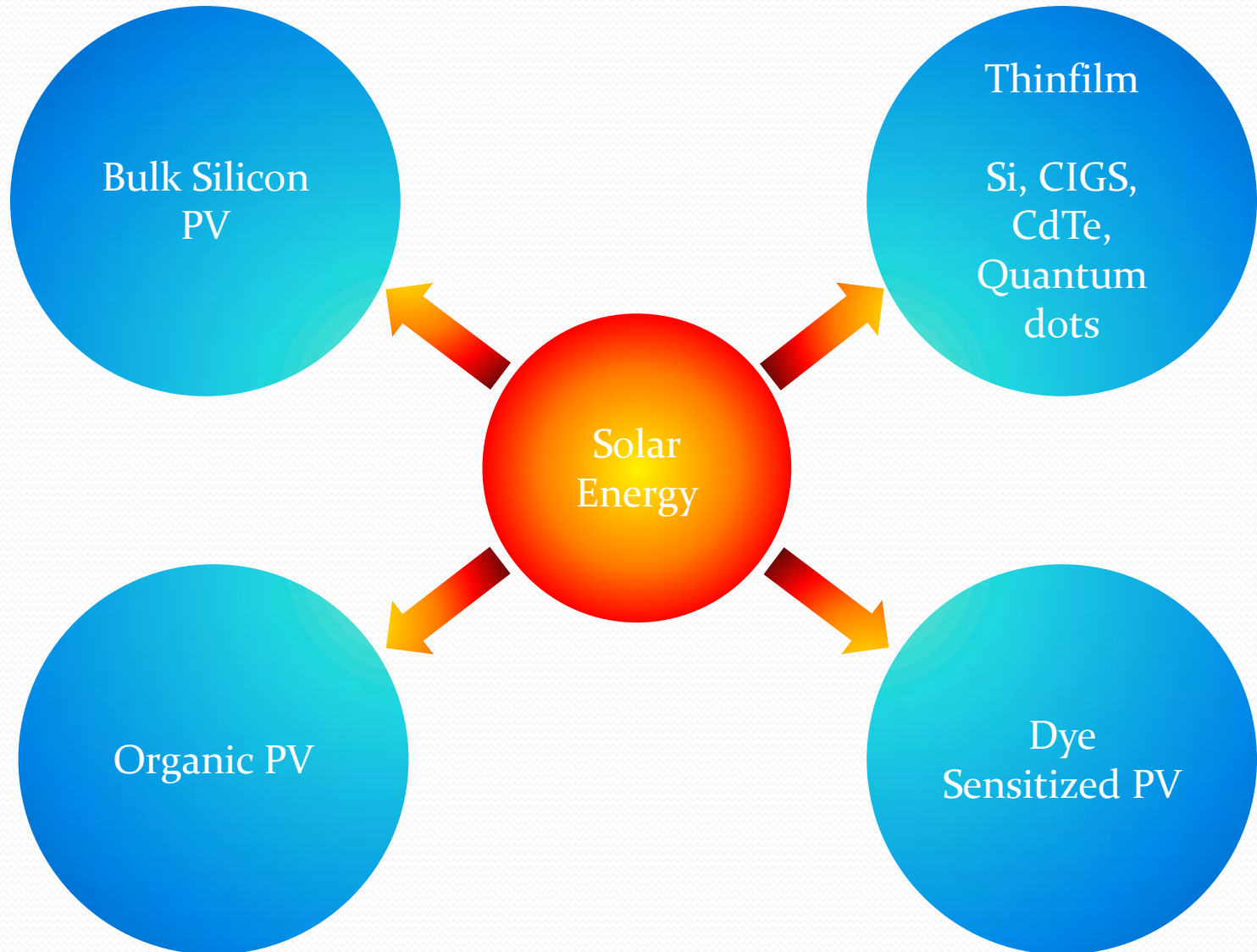
- Presently around 90 companies in India
- 9 manufacturers of solar cells
- 19 manufacturers of PV modules.
- Total manufacturing capacity:  
2009 – 700 MW  
2017 – 4000 to 5000 MW
- Polysilicon manufacturing: 2017 – 2000 MW

- Tata BP Solar is currently investing **US\$100 million** in manufacturing in India.

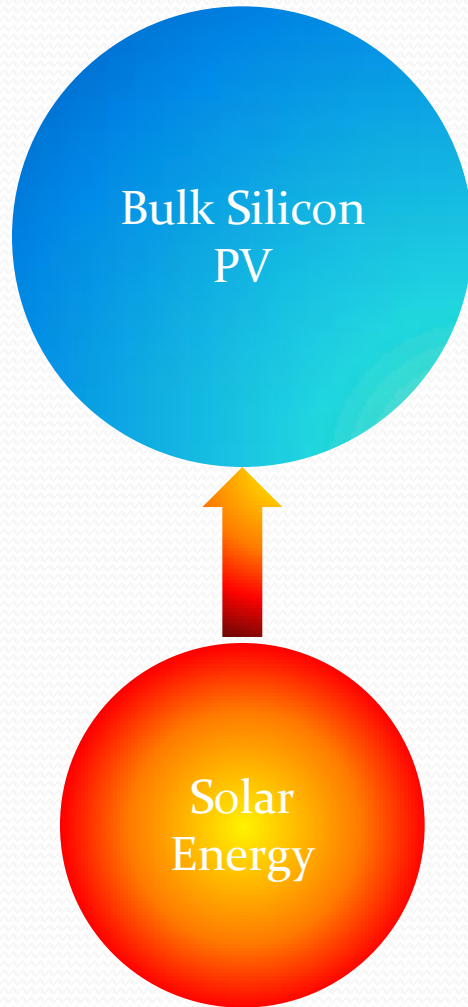
## Media announcements on investments

- Moser Baer PV: **\$450 million**
- US based Signet Solar: **\$2 billion including R&D**
- US based Solar Semiconductor: **\$40 million+\$330 million from private equity**

# Thrust areas for PV in India



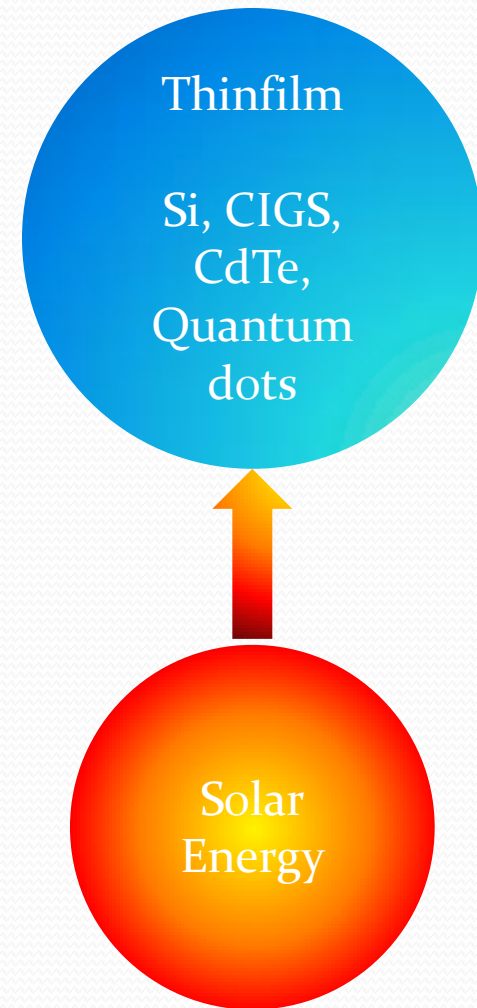
# Bulk Silicon PV



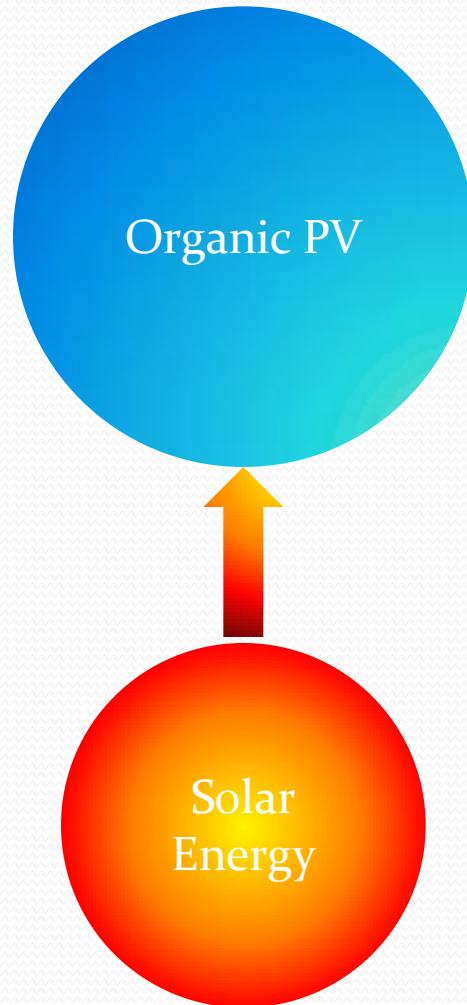
- Advantages:
  - Mature technology
  - Commercial efficiency >15%
  - > 87% of market share currently
  - Consistent decrease in price per watt-hour energy
- Challenges:
  - Expensive compared to coal based electricity

# Thin-film PV

- Advantages:
  - Has the potential of being relatively cheap & light weight
  - Recent development of spray-painted CIGS, but needs research
  - Quantum dots based films can show high efficiency (>60%)
  - Efficiency: 10 (commercial)
- Challenges:
  - Environmental issues (CIGS & CdTe)
  - Very advanced/expensive technologies may be required



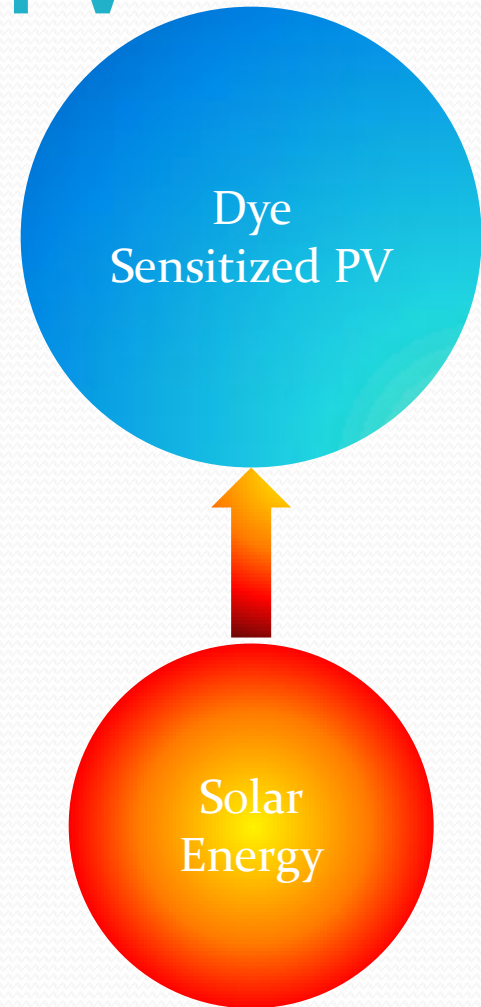
# Organic PV



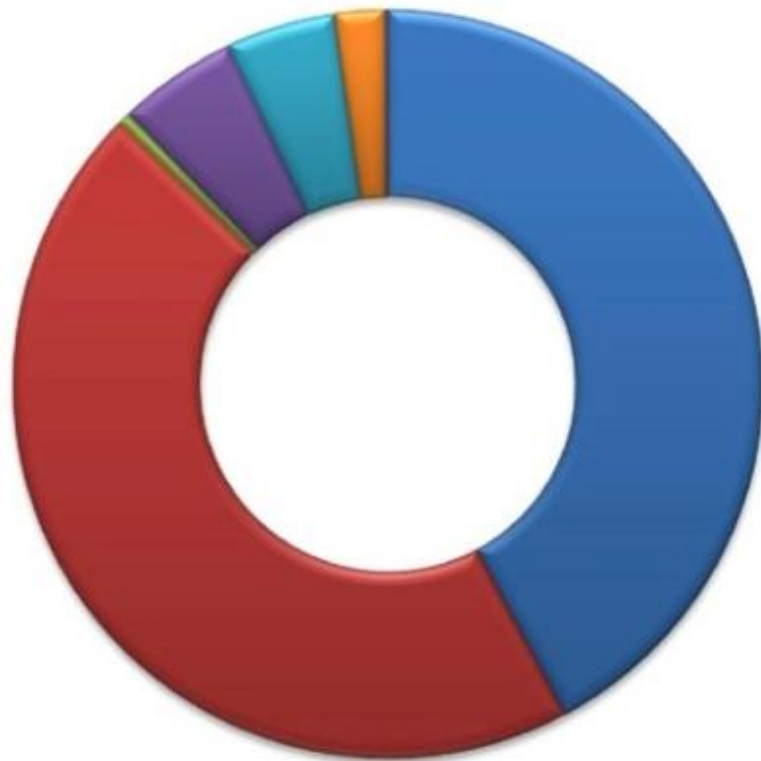
- Advantages:
  - Potential of being very cheap
  - Potential of easy full scale production
  - Already lab scale efficiency of 6.5% demonstrated.
  - Flexible solar cells could be manufactured
- Challenges:
  - Presently not thermally stable for the expected life span of 20 year.

# Dye-sensitized PV

- Advantages:
  - Potential to be very cheap
  - Already lab scale efficiencies of 10.5% demonstrated
  - Flexible solar cells could be manufactured
  - Potential of easy full scale production
- Challenges:
  - Production of full-size panels yet to be demonstrated



# Market share of PV technologies



■ monocrys-Si (42.2%)

■ multicrys-Si (45.2%)

■ CIS (0.5%)

■ a-Si/micro-Si (5.2%)

■ CdTe (4.7%)

■ Ribbon c-Si (2.2%)

■ others (0.1%)

**Bulk Si**  
**>87%**

# Materials for Solar Cells

PV Technology	Material Avail. (>30GW/yr by 2020)	Toxicity	Module $\eta > 15\%$ (2020)	Reliability	Mat. Utilization (2020)
mc-Si	Abundant	None	~ 19%	Proven	> 100 $\mu\text{m}$
Mono-Si	Abundant	None	~ 20%	Proven	> 100 $\mu\text{m}$
Ribbon Si	Abundant	None	~ 17%	Proven	> 80 $\mu\text{m}$
a-Si/ $\mu\text{c-Si}$	Abundant	None	~ 12%	Improving	~ 2 $\mu\text{m}$
CIGS	In, Se	Se	~ 16%	Improving	~ 2 $\mu\text{m}$
CdTe	Te	Cd	~ 14%	Improving	~ 2 $\mu\text{m}$
Dye-Sensitized	Ru, Others?	Ru Others?	~ 11%	Poor	~ 7 $\mu\text{m}$
Organic	Abundant	Probably Ok	~ 10%	Poor	< 1 $\mu\text{m}$
Nanostructured	Abundant	Probably Ok	~ 17%	Packaging?	~ 1 $\mu\text{m}$

\*mc-Si is likely to be #1 in 2020 if high-quality thin Si (~ 20  $\mu\text{m}$ ) can be developed

# R&D activities in India

Indian Institutes	R&D activities
Indian Institute of Technology, Bombay	Concentrated solar cells with high thermal stability
National Physical Laboratory	Dye-sensitized solar cells
Indian Institute of Science, Bangalore	Low cost grid connectivity systems
Centre for Materials for Electronics, Pune	Controlling diffusion in bulk Silicon PV
Indian Association for Cultivation of Science, Kolkata	Amorphous Silicon based PV
Delhi college of Engineering, Delhi	Solar powered car
Indian Institute of Technology, Delhi	Nano-composite Copper oxide thin film PV

# Solar Power = Social Improvement

- **More economical** than conventional where village located more than 10 km from the main electricity grid line.
- Solar lights and power have transformed lives of villagers:
  - Working hours extend into night - **Family's income level goes up**
  - Kerosene lamp and its accompanying fumes dispensed with - **Family's health improves**
  - Children can **study** at night
  - Women can **finish household chores**
  - Television set - opens up **a new world** of information, entertainment and education

# Acknowledgement

- TATA BP Solar India
- McKinsey Reports
- TCE Consulting Engineers
- Web and media reports

THANK YOU