EMERGING GREEN INDIA
FOSTERING RENEWABLE & CLEAN TECHNOLOGIES FOR POWER GENERATION

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INDIA

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INDIA
States and Union Territories
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AFGHANISTAN
PAKISTAN
CHINA
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BANGLADESH
MYANMAR
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Srinagar
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LEGEND
International Boundary
State Boundary
Country Capital
State Capital
Map not to Scale
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This map is updated as on June 12, 2012
INDIAN OCEAN

India As A Country

- **2nd Largest population in the world-1.3 billion.**
- **2nd Fastest Growing Economy In The World.**
- **80% of India will be built in the next 20-25 years.**
- **Plenty of Sunshine Round The Year.**
- **Long Sea Coastline of 5100 km.**
- **Many Large (12) & Small rivers.**

India As A Country (cont)

- **14500Km of inland navigable waterways.**
- **56% of Land is arable and used for Agriculture.**
- **Only 35% of Ground Water Resources Utilized.**
- **Coal Reserves over 1000 million tonnes.**
- **India depends upon Oil imports of 70 %.**
- **Hydro-electric potential-250000 Mw. Only 17% harnessed.**
- **Highest Cattle Population in the World. Plenty of Animal waste.**

World Energy Scenario

- **World population expected to reach 8 billion by 2030.**
- **40% more energy required in 2030 than used today mainly by developing countries like India.**
- **In 2005, 81% of energy used worldwide came from fossil fuels.**
- **Oil the most used fuel(35%) followed by coal (25%) & natural gas (21%).**
- **In spite of GHG, coal expected to continue as a "Reliable" & "Mature" fuel.**
- **Environmental concerns to reduce GHG (Green House Gases).**
- **Renewable Energy enlarging its share but constrained by higher cost of generation.**

Green House Gases (GHG)

- **Increasing industries & energy generation in emerging economies of the world contribute to higher GHG emission.**
- **India has large population over 1 billion.**
- **Annual per capita energy consumed in India = 500kwh.**
- **Annual per capita GHG emission in India = 1.2 tonnes.**

GHG (Green House Gases)
The Root Cause of Clean & Renewable Energy Evolution

- **The GHG Traps The Earth's Heat in the Atmosphere. It Includes Water Vapor, Methane & CO2.**

- **Greenhouse Effect is 'Rise in Temperature on the Earth Thereby Increasing the Temp of Earth's Land & Water'.**

- **National Mission for Enhanced Energy Efficiency (NMEEE) India, by way of its Initiatives in the next 4 years plans to Save 19598 Mw of Electrical Energy which would have otherwise lost and increased the GHG Emissions.**

Reducing C02 Emissions in Fossil Fuel Power Generation

1) Higher Efficiency, Super Critical Power Plants.

2) IGCC (Integrated Gasification Combine Cycle).

3) Using variable speed drive motors in place of constant speed drive motors.

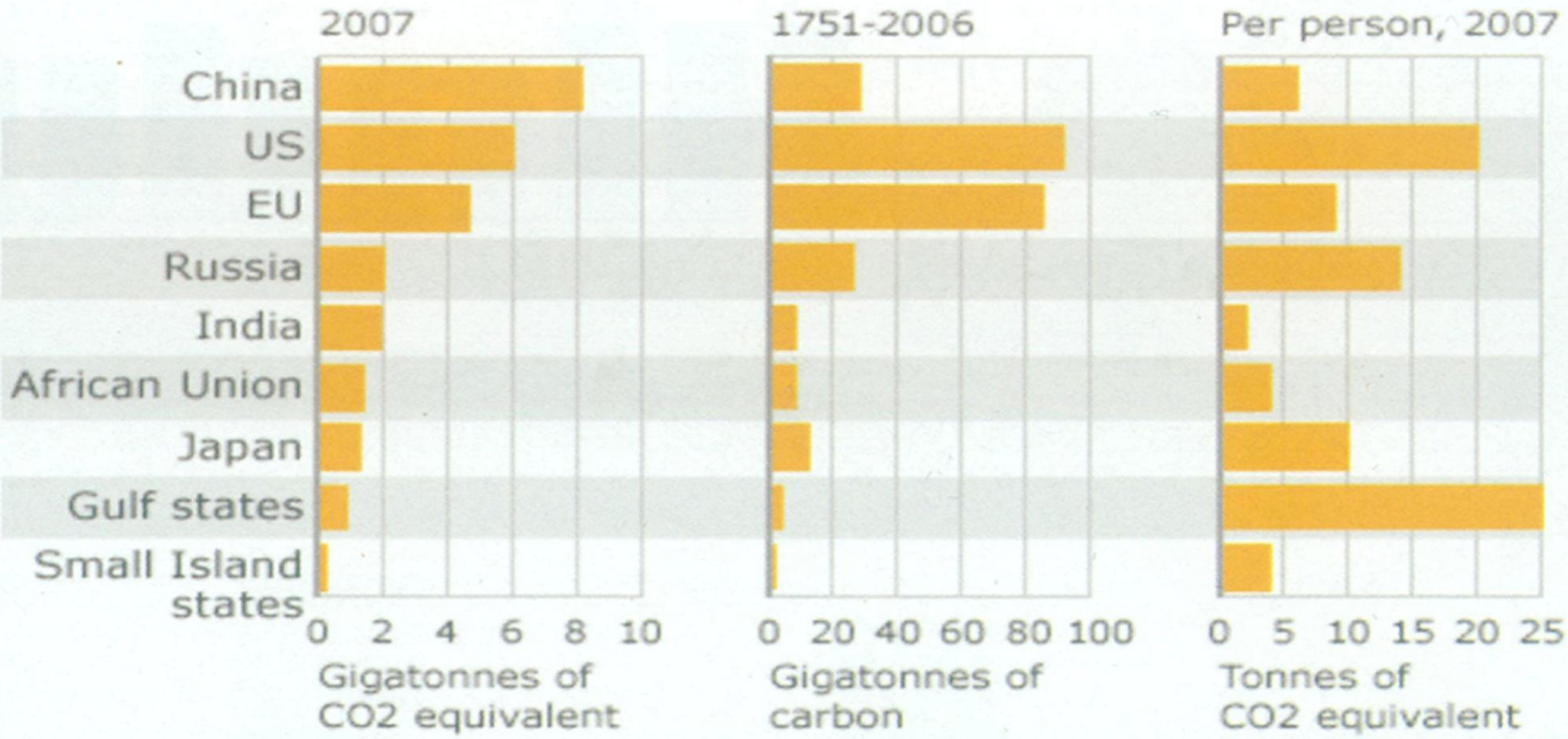
4) Demand Side Management in The Electric Power Distribution System.

5) Enlarging Share of Renewable Power.

BBC News: Monday, 24th, December, 2009

http://news.bbc.co.uk/2/hi/asia-pacific/8411768.stm

Three different ways to look at carbon emissions

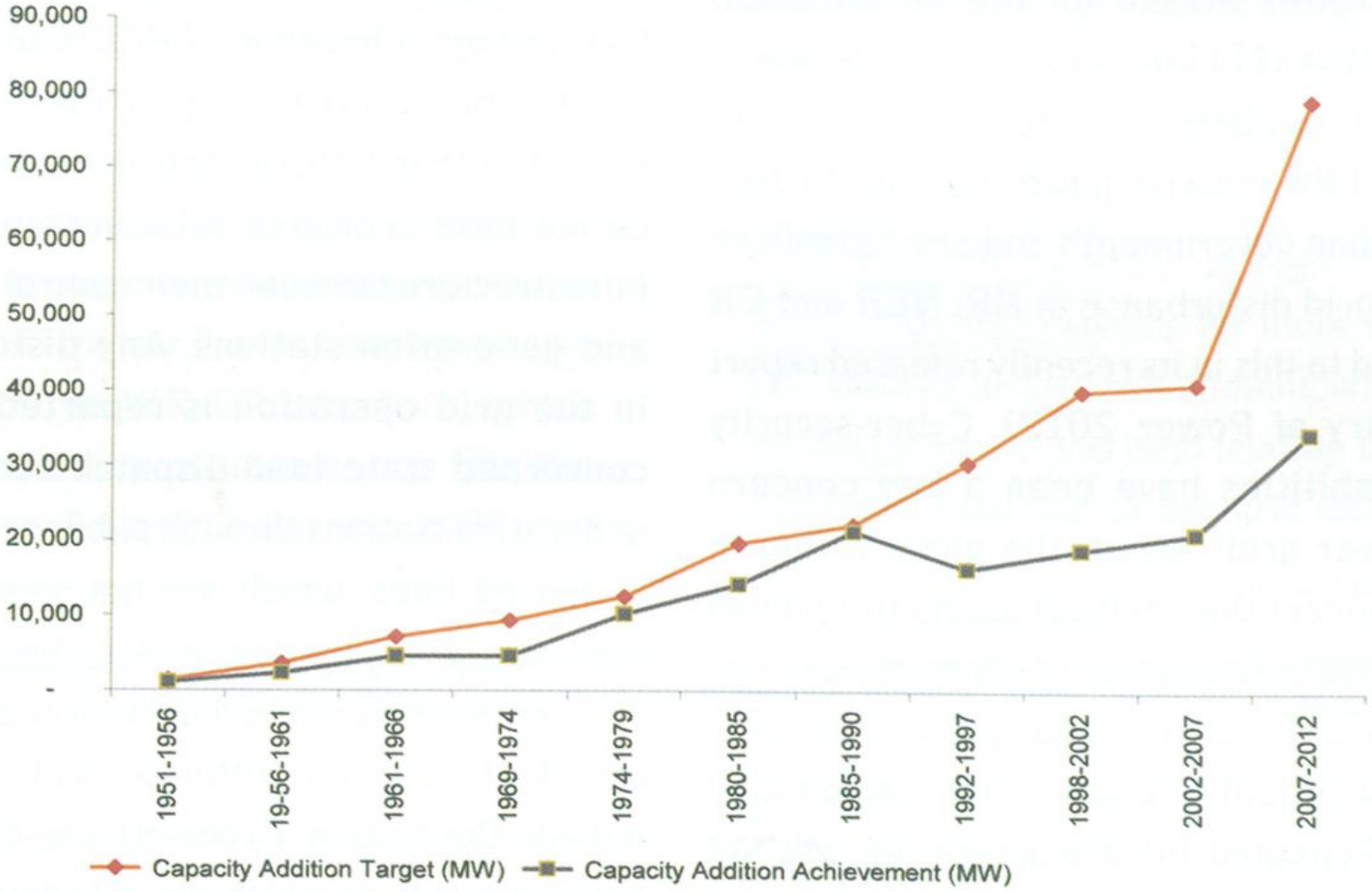


Sources: CDIAC, Potsdam Institute for Climate Impact Research

Electricity Development in India

- **10th Nov 1897- First Time Electric Power Generated.**
- **1900s: Diesel Power Generation.**
- **1930s: Coal-Fired Power Generation.**
- **1960s: Nuclear Power Generation.**
- **1970/80s: Natural Gas-Fired Power Generation.**
- **1980s: Wind Power Generation.**
- **2010s: Solar Power Generation.**

Figure 1: Power Market, India, Capacity Addition Targets and Achievements during Five Year Plans, 1951–2012



Source: GlobalData; Indian Ministry of Power, 2011

Note: * The Eleventh Five Year Plan includes data for the 2007–2012

Present Power Generation Scenario of India

- **Total Installed Generation capacity** **1,75,000 MW**
- **Addl. Generating capacity needed in next 6 years (Investments of US$ 400b)** **1,00,000 MW**
- **Present Base of Grid Interactive Renewable Power(RP)** **20,000 MW**
- **RP capacity to be added annually** **2500 MW/Year**
- **National Solar Mission's Target Addition (by 2022)** **20000 MW**

(Source: ELECRAMA 2012)

Present Power Generation Scenario of India

- **Over 30% of rural population has no access to electricity.**
- **For sustained economic growth, the gap between Demand & Supply of electricity needs to be bridged.**
- **Coal shares more than 70% of electricity generation.**

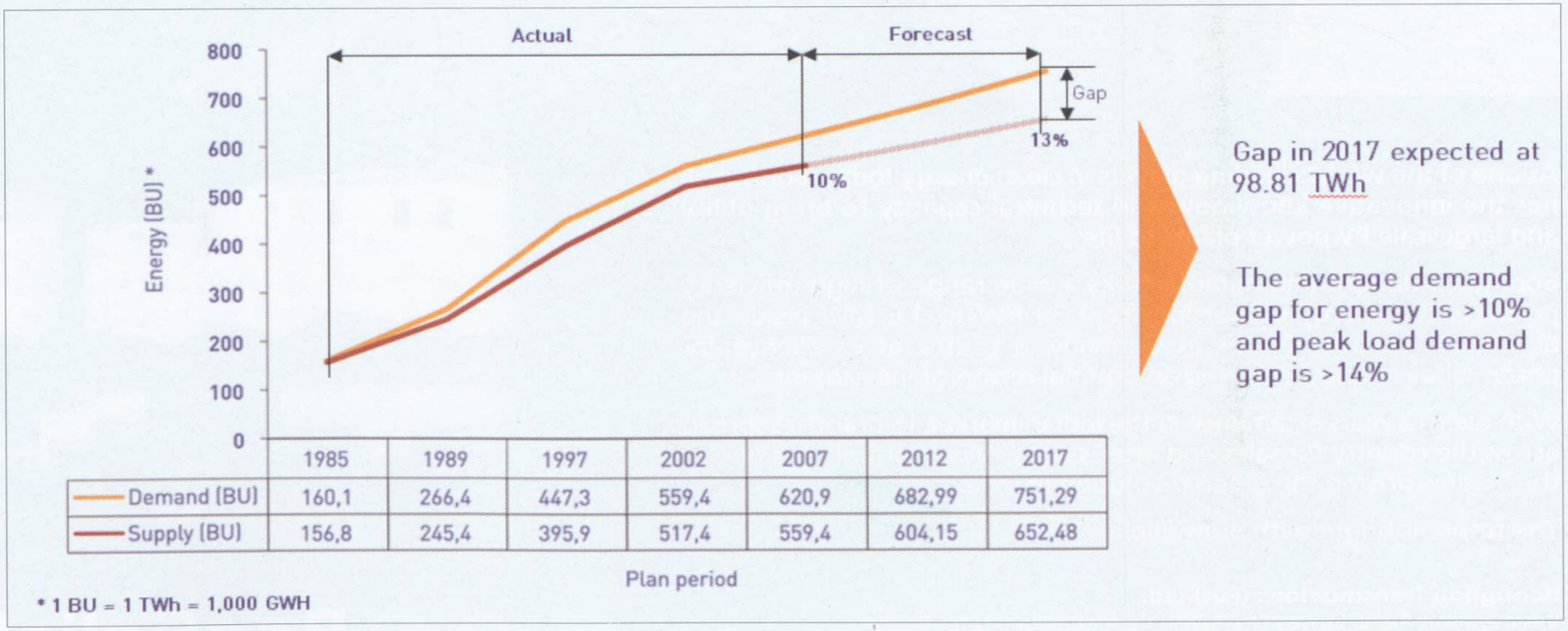
  Of the 54000Mw capacity added between 2007-2012, over 70% was coal based.
- **Coal fired generation, a major factor in CO2 emission, the use of advanced technology in recent times rapidly changing the scenario.**
- **Supercritical (once through) technology steam power plants notably meet the requirements for higher efficiencies to reduce both, fuel costs and CO2 emissions.**
- **Share of Renewable Energy (Green Energy) about 10% will need enhancement.**

Dominance of Fossil Fuels In Electric Power Generation in India

	GW	%
• Thermal (Coal & Gas)	104	64.2
• Nuclear	4.5	2.8
• Hydro	37	22.8
• Renewable Energy (Biomass, Wind & Solar)	16.56	10.2
Total	162	100

Electricity Generation & Transmission & Distribution in India

- Electricity Demand & Supply



	1985	1989	1997	2002	2007	2012	2017
Demand (BU)	160,1	266,4	447,3	559,4	620,9	682,99	751,29
Supply (BU)	156,8	245,4	395,9	517,4	559,4	604,15	652,48

Renewable Power Development in India

	Present Capacity (MW)	Future Growth (MW)
• Solar	1044	20MW per sq.km
• Wind	17967	20000
• Biomass	3412	20000
• Small Hydro	3434	10000
• Geothermal	Nil	10600
• Tidal	Nil	Nil
Total:	25857	

Grid Interactive Renewable Power
Cumulative Achievements in MW up to 31 March 2010

- **Biomass Power (agro residue) = 865.60**
- **Wind Power = 11870.00**
- **Solar Power = 10.28**
- **Small Hydro Power = 2735.42**
- **Cogeneration (biogases) = 1334.03**
- **Waste to Energy = 64.96**

TOTAL (A) = 15817.29

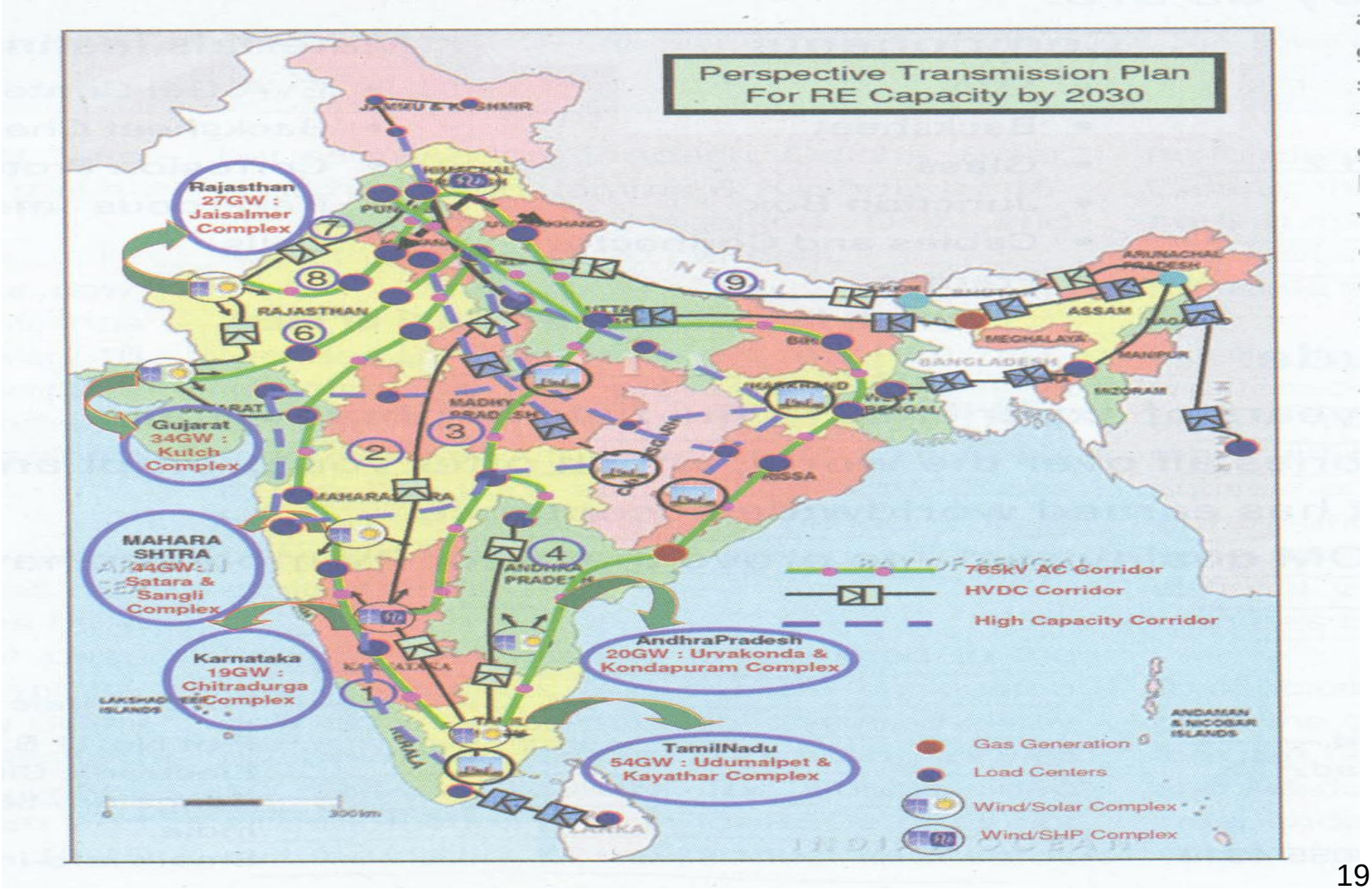
Off-Grid / Renewable Power
Cumulative Achievements in MW up to 31 March 2010

- **Biomass Power = 232.17**
- **Biomass (gasifier) = 122.14**
- **Waste to Energy = 46.72**
- **Solar PV Power Plants = 2.46**
- **Aero-generation/Hybrid system = 1.07**

TOTAL (B) = 404.56

TOTAL of (A) & (B) = 16221.85

Perspective Plan for Renewable Energy Transmission in 2030



Challenges Facing The Renewable Sector In India

- **Land Acquisition.**
- **Obtaining Clearances Particularly Forest Clearances.**
- **Non-Remunerative Regulatory Tariffs.**
- **Renewable Energy Certificates (REC).**
- **High T & D losses.**

Solar Power Generation

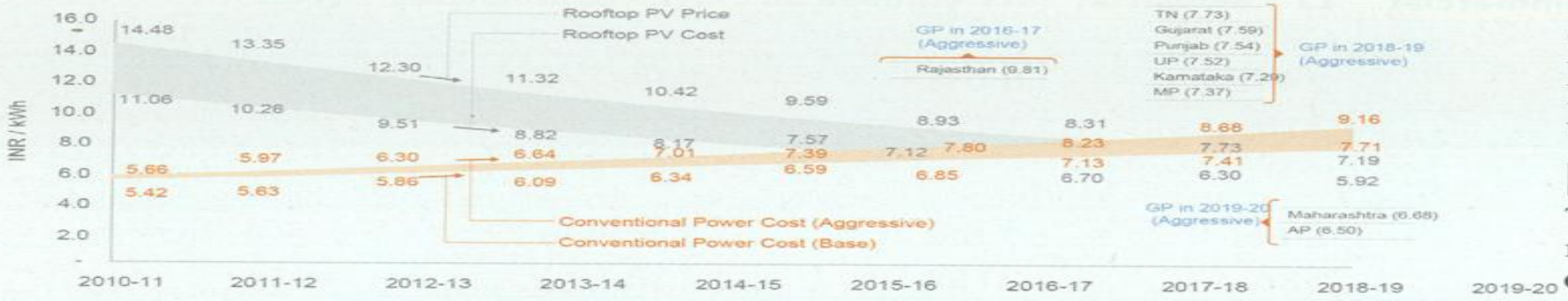
- **India Well Endowed with high Solar Insolations. (Avg 6kwh per sq.m2 per day).**
- **Availability of Large Space for Installing PV Solar Panels in Urban Areas difficult.**
- **Reluctance to permit solar PV on a common roof top terrace shared by the residents of the apartment buildings.**
- **The rural area on the other hand especially the semi arid regions, wasteland and ravines is ideal to accommodate the sprawling solar PV panels.**

Solar Power Generation (Cont)

- **Massive fly ash produced at coal fired power stations can fill up the large uneven waste lands to install PV panels.**
- **605 Mw of CSP allocated in India since 2010.**
- **Under Phase I of NSM, 7 projects with sizes ranging from 20Mw to 100Mw and total 470Mw allocated.**
- **MNRE looking to set up pilot projects for testing the CSP technology as under:**

  Testing for storage (10Mw), for high operating temp.(500deg C), hybrid cooling (30% water) in combination with biomass (solar usage 60%), in combination with natural gas(gas usage (30%), augmenting a coal based power plant and in combination with a Stirling engine(an external combustion air engine)

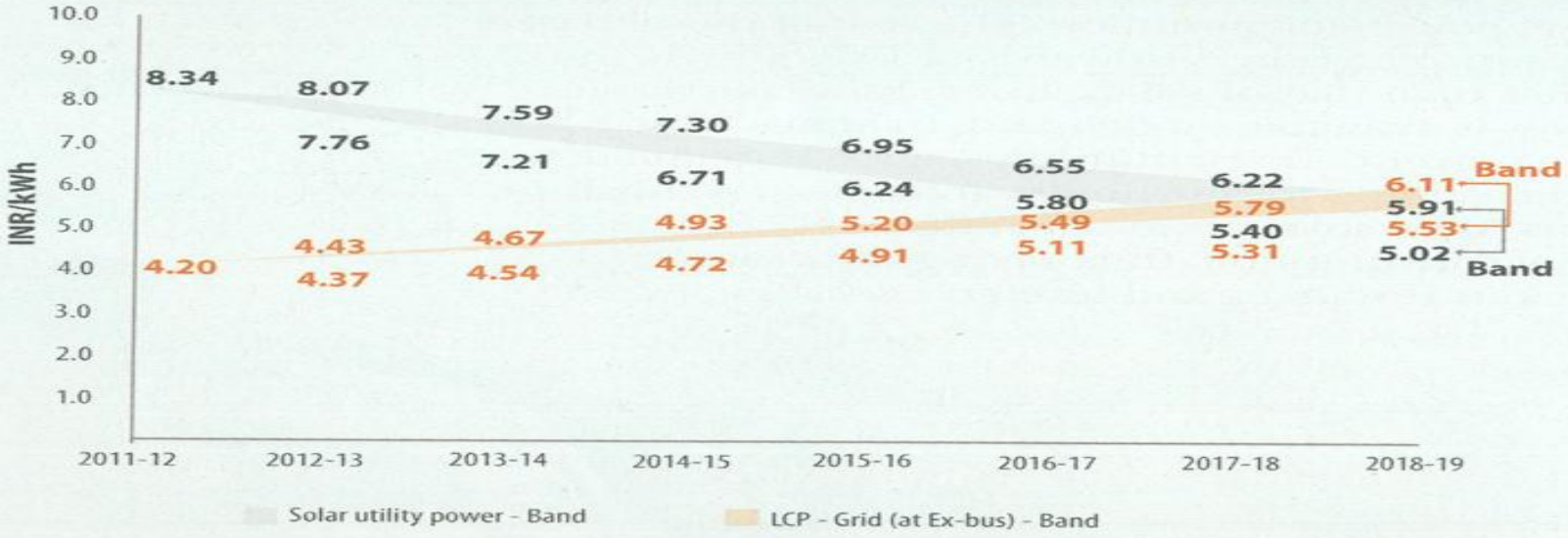
Rooftop PV cost vs. conventional power cost at consumer–end



Grid Parity (GP) Year	Aggressive Case	Base-Case
Rooftop PV Price	2017-18	2019-20

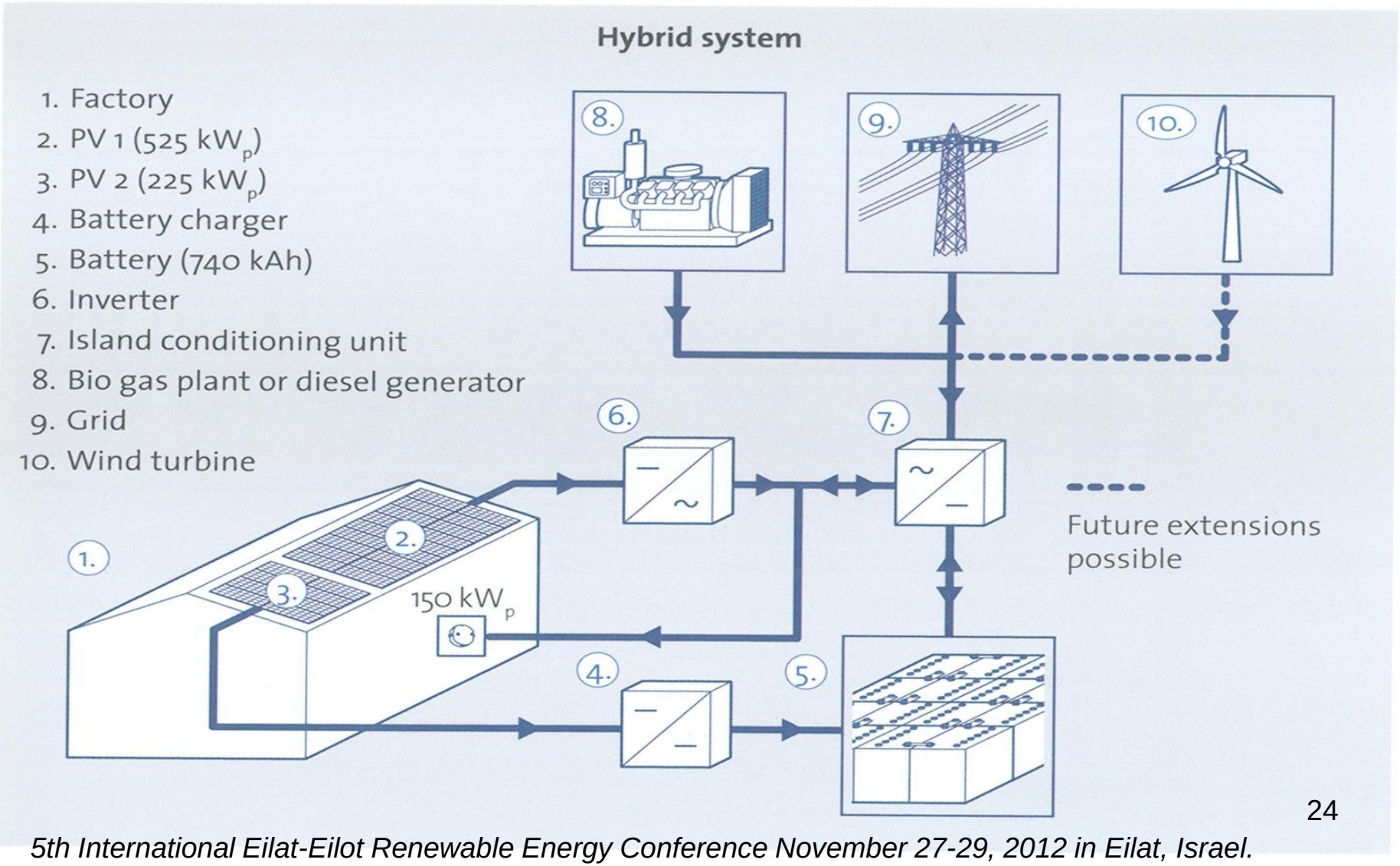
Source: KPMG's Solar Grid Parity Model

Grid parity for solar power – utility level



Source: KPMG's Solar Grid Parity Model

Hybrid System



Wind Power Generation

- **India's long sea coast and a few inland areas offer opportunities in Wind Power.**
- **In the initial stages (1980-90's) problems encountered collapsing of blades.**
- **Saline Corrosion.**
- **Wind turbines not optimally aligned.**
- **Wind turbine unable to rotate at low wind speeds.**
- **Low Annual Load Factor below 20% This will improve to 27% and above with better technologies.**

Wind Power Generation (cont)

- **Wind Power Policy-2007 of Gujarat State.**
- **The State of Gujarat has the highest wind power in the country-9675Mw.**
- **At 1380Mw, Gujarat State ranks 3rd in generation capacity in the country.**
- **Wheeling permitted within the State.**
- **Renewable Purchase Obligation (RPO) between the RE Producer & Distribution Licensee.**
- **Subject to regulations of Gujarat State Electricity Regulatory Commission. (GERC)**
- **Gujarat Energy Development Agency is the nodal agency to implement the Wind Power Policy-2007.**

Biomass Power Generation
Waste to Energy

- **Biomass is plants and animal matter and when used as fuel is called bio fuel which is renewable.**
- **Largest population of cattle in the world, Hence abundance of animal dung which is used as a cooking fuel in the rural households.**
- **All cities of India densely populated by people and having sewage disposal plants.**
- **Large quantity of garbage waste collected and transported by the municipalities to land filling sites.**
- **This is a burden and causes unhygienic conditions and methane gas at the disposal sites.**
- **The rising piles of garbage in urban areas in India estimated at 150 million tones have power generation potential of 15000 Mw of distributed power.**

  Planning installation of 1 million biogas plants

Jatropha Curcas for Bio-Fuel

Small Hydro Power (SHP) Plants
Present Scenario

- **India is endowed with many rivers large & small.**
- **An addition of 45000MW hydro capacity expected in the next 10 years.**
- **Many large rivers have dams to generate hydro power and discharge water for irrigation/drinking purpose.**
- **A large number of small rivers or river streams which have no check- dams and hydro turbines to generate electric power.**
- **Unlike large rivers, water flow data is not available for small rivers and streams. In this scenario, water flow data is calculated on the basis of rainfall statistics.**
- **Hence in monsoon season(3-4 months of the year), flood water from the river flows out and makes the rivers dry in winter/summer.**

Small Hydro Power (SHP) Plants
Present Scenario (cont)

- **The hydro sector worldwide, is a durable source and offers growth opportunities, especially in developing countries like India.**

- **For SHP, the Plant Load Factor ranges from 30% to 50% and above depending upon the seasonal rainfall.**

- **States like Himachal Pradesh, Karnataka, Jammu & Kashmir, Arunachal Pradesh, Uttarakhand, Madhya Pradesh, Tamil Nadu, Maharashtra and Kerala have water resources for SHP**

GEOTHERMAL ENERGY

GEOTHERMAL ENERGY FOR GENERATING ELECTRICITY

Clean: No emissions, safe to use

- **Reliable: Continuous, reliable base-load power**
- **Sustainable / Reusable: Water can be recycled back into the earth and reused**
- **No other fuel mixture required to create electricity**

Land Conservation: No major land requirements. Can be integrated into the local area with no adverse effects

Flexible / Modular: Geothermal power plants can have modular designs, with additional units installed in increments when needed to fit growing demand for electricity

Tidal Wave Energy

Project Feasibility in Gujarat State:

- **India's Long Sea Coastline of 5100 Km**
- **No Tidal Wave Power In India Yet.**
- **Gujarat State has 1600 km of Sea Coast on the Arabian Sea**
- **Feasibility of Tidal Wave Power identified by UNDP in 1975.**
- **A Reconnaissance Report prepared by Govt. of Gujarat in 1988-89 called 'Kalpasar Project".**
- **Kalpasar Project Location is Gulf of Khambhat in the Arabian Sea waters.**

Tidal Wave Energy (cont)

This Multi-purpose Project envisages:

- **Creation of a fresh water reservoir by constructing a dam across the Gulf.**
- **Tidal Power basin receiving Arabian sea waves**
- **Tidal Power generation- 5880 Mw. Project Cost Rs.44300 billion (900 billion US$)**

Tidal Wave Energy in Gujarat

Drivers of Renewable Power Growth in India

1) At National Level:

- **Strategic Plan for New & Renewable Energy Sector for The Period(2011-2017) Prepared by MNRE of Govt. of India**

- **Jawaharlal Nehru National Solar Mission(JNNSM)**

Drivers of Renewable Power Growth in India

2) At State Govt. Levels

- **Solar Policy & Wind Policy formulated by many states Gujarat State being the first to do so.**
- **State Govt's. thrust to make Solar Hubs and Solar Cities, Gujarat State, India's Growth Engine, Being One of Them to Set up Solar Park in North Gujarat.**
- **Gujarat State shares 22% of Indian Exports with 5% Population of The Country.**
- **40% of Gujarat State's electricity is Consumed to Draw Water from Underground bore wells. Gujarat State is Promoting Micro-Irrigation Devices for Economic use of scarce Water.**
- **Gujarat State promoting Water Recycling and Management of solid & Liquid Urban Waste.**
- **Gujarat State Organizing Global Business Investors Meet in 2013 (held every 2 years since 2003).**

Drivers of Renewable Power Growth in India

3) At International Level:

India-USA Clean Energy Partnership Initiative.

- **Out of 5 Working Groups, One Group dedicated for promotion of 'New Technologies & Renewable Energy**
- **Growing Bilateral Civilian Trade between India & Israel now over 7 billion US$**
- **A recent visit of Govt. of India Energy Delegation to Israel for Exploring Energy Collaborations.**
- **Countries like USA, Germany, Spain, France, Italy, Israel, China & Japan Interested in Solar Power Development.**

1 MW PV Solar Plant built on Narmada River Canal Ahmedabad of Gujarat State Electricity Corporation Ltd.

- **Location: Village: Chandrasan, Taluka: Kadi, District: Mehsana Gujarat state.**
- **Coordinates: Longitude: 23.0*N/Latitude: 72.24*E**
- **Projected energy production: 1568 kwh/kwp/year (1.5 million Units/year/MW)**
- **Irradiation: 4.6 – 6.4 kwh/m3**
- **Installed Capacity: 1 MWp**
- **Technology: Polycrystalline Solar Modules 280Wp**
- **No. of Modules: 3616, Canal Length used: 750 mtr**
- **Inverter Supplier: Power One, Italy**
- **Compact Sub-Station Supplier: ABB Ltd.**

1 MW PV Solar Plant built on Narmada River Canal Ahmedabad of Gujarat State Electricity Corporation Ltd. (cont)

- **No. of Blocks: 8 blocks each of 125Kw, No. of Inverters: 4Nos**
- **Power Evacuation System: 11KV, Stack Holder: Owner: GSECL**
- **Canal Property: SSNNL, Financial Assistance by: NABARD**
- **Power off Taker: UGVCL**
- **EPC Contractor: M/S SunEdison India Pvt. LTD.**
- **Module Manufacturer: M/S MEMC. USA**
- **Inverter Supplier: Power One, Italy**
- **Compact Sub-Station Supplier: ABB Ltd.**

1 Mw Canal Top PV Solar Plant in Gujarat

Concluding Remarks

- **Notwithstanding the Adverse GHG effect, Coal expected to continue as a Mature Fuel.**
- **Higher prices of Coal (Indian & Imported) to narrow The gap in Generation Cost of Fossil Fuel plants and Renewable Power Plants.**
- **With Large addition of Coal fired power plants of 660/800mw ratings to meet the demand, the generation mix of Conventional Power & Renewable Power will remain around 90:10**
- **70% Rural India living on vast land area and long sea coast, is more suitable to Renewable Power through PV solar, wind & biomass.**

Concluding Remarks (cont)

- **Distributed Generation and Micro grids in rural areas.**

- **India with its 70% agriculture backbone, the farmers will need to be educated to changeover, their old overrated water pump-motor sets to the latest designs to bring down the electricity consumption and water wastage. Drip Irrigation systems pioneered by Israel in India can save the scarce underground water.**

- **For proliferation of Renewable Energy in Rural areas, educating the rural masses with the support of local govt. bodies, village panchayats (apex authority) essential.**

EVERY RENEWABLE ENERGY KILOWATT THAT PERMANENTLY ELIMINATES A COAL KILOWATT IS A WIN WITH A SOCIAL VALUE AND LOCAL ECONOMY IMPACT

THANK YOU