Renewable Energy in India

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Presentation Structure

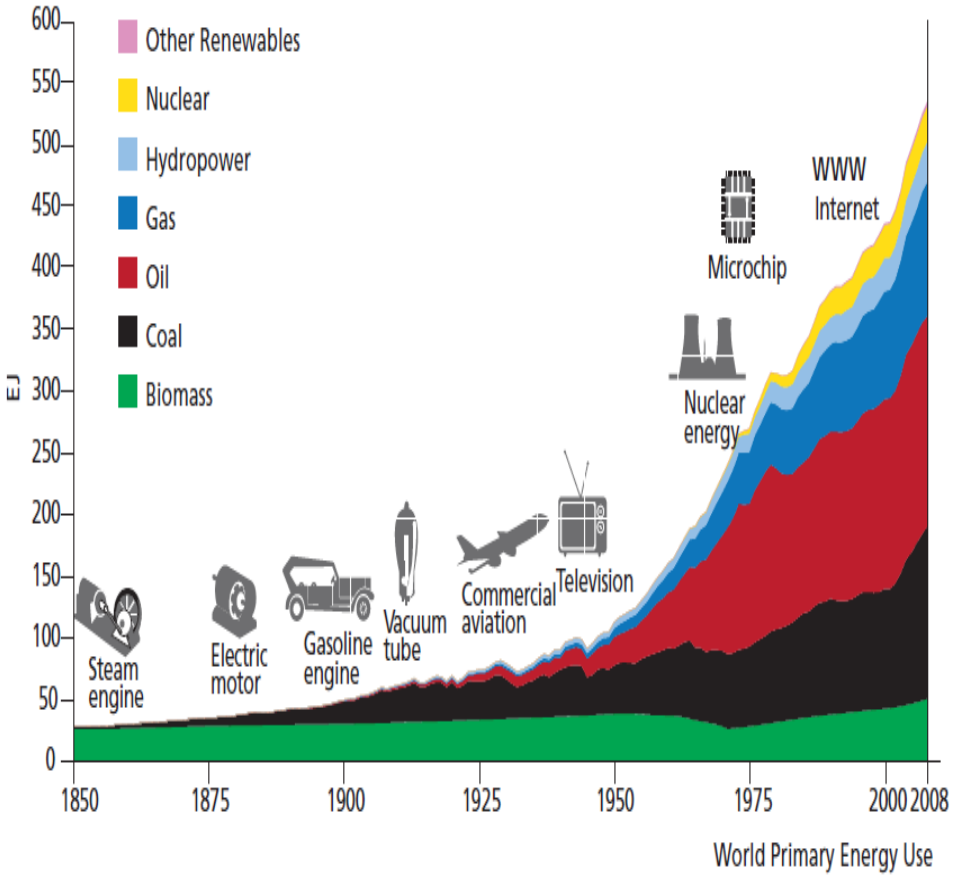
Trends

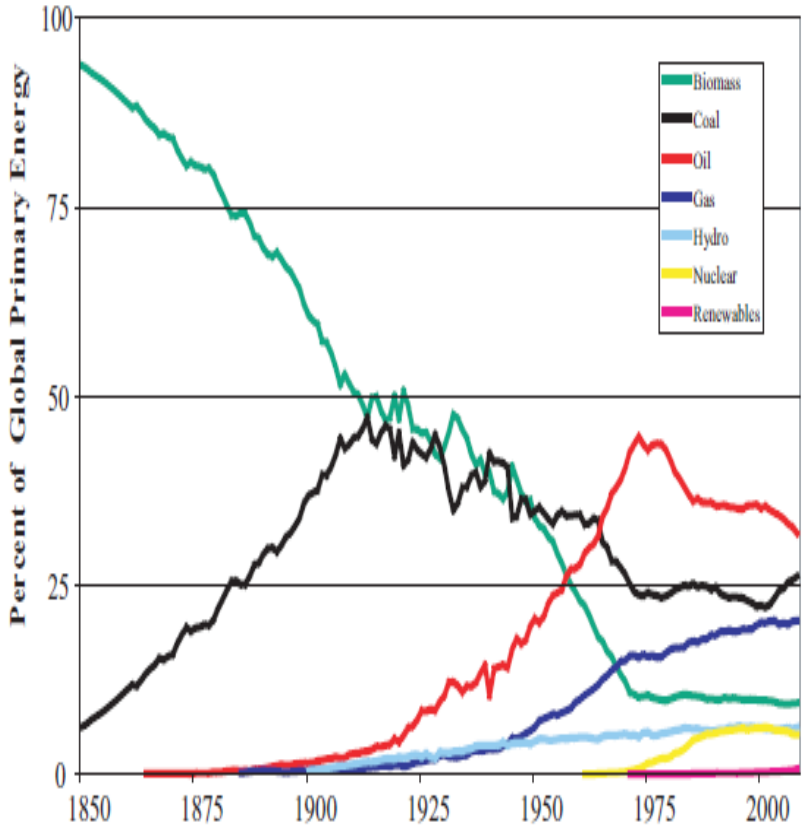
Defining Renewable Energy

Renewable Energy-Global trends

Renewable Energy-India context

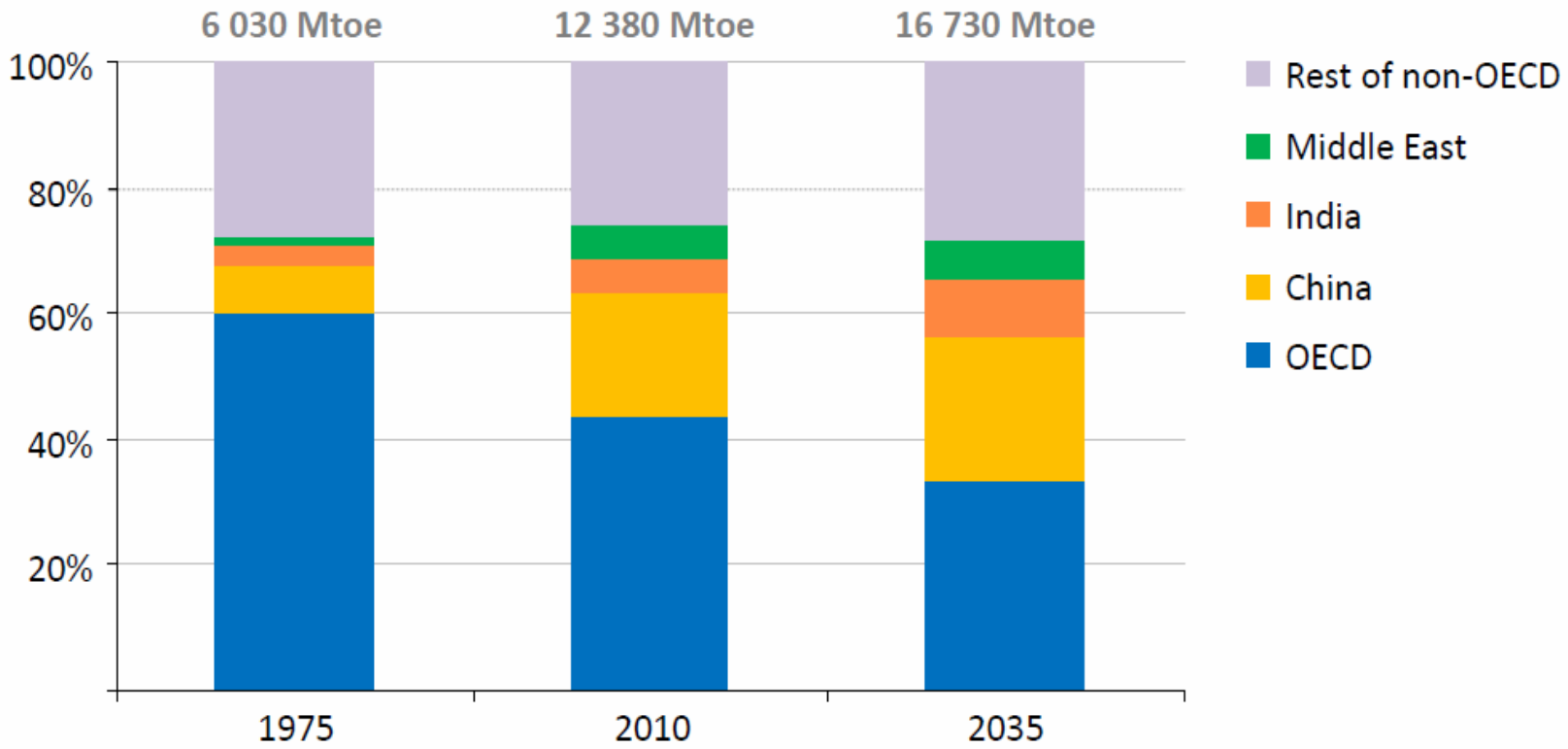
Energy is a vital to our way of life- Global energy mix has changed over period





Source: updated from Nakicenovic, N Grubler,A , McDonald, A (1998) IIASA

World commercial energy demand is on the rise



Global energy demand rises by over one-third in the period to 2035

Source: IEA, World Energy Outlook 20112

Defining Renewable Energy

Defining Renewable Energy

- ***Any form of energy from solar, geophysical, or biological sources that is replenished by natural processes at a rate that equals or exceeds its rate of use*** ***(World Energy Assessment 2012)***

- **Non-fossil energy sources such as wind, solar, geothermal, wave, tidal, hydro-power, biomass, land fill gas, sewage treatment plant gas and biogas** ***(European Union under its directive 2001/77/EC dated 27 September, 2001)***

- **Solar energy, wind energy, hydropower, biomass energy including biofuels, and geothermal energy** ***(Political Declaration of the International Conference for Renewable Energies 2004)***

- **In general parlance the term renewable energy refers to biomass energy, hydro energy (low impact), solar energy, wind energy, geothermal energy, and ocean energy (tidal, wave, current, ocean thermal and osmotic energy)**

Wind Power Applications

Technology type	System	Application
Wind power - electrical	Grid connected	• Supplementing mains supply
Wind power - electrical	Stand-alone, battery charging	• Small home systems • Small commercial/community systems • Water pumping • Telecommunications • Navigation aids
Wind power - electrical	Stand-alone, autonomous diesel	• Commercial systems • Remote settlements • Mini-grid systems
Wind power - mechanical	Water pumping	• Drinking water supply • Irrigation pumping • Sea-salt production • Dewatering
Wind power - mechanical	Other	• Milling grain • Driving other, often agricultural, machines

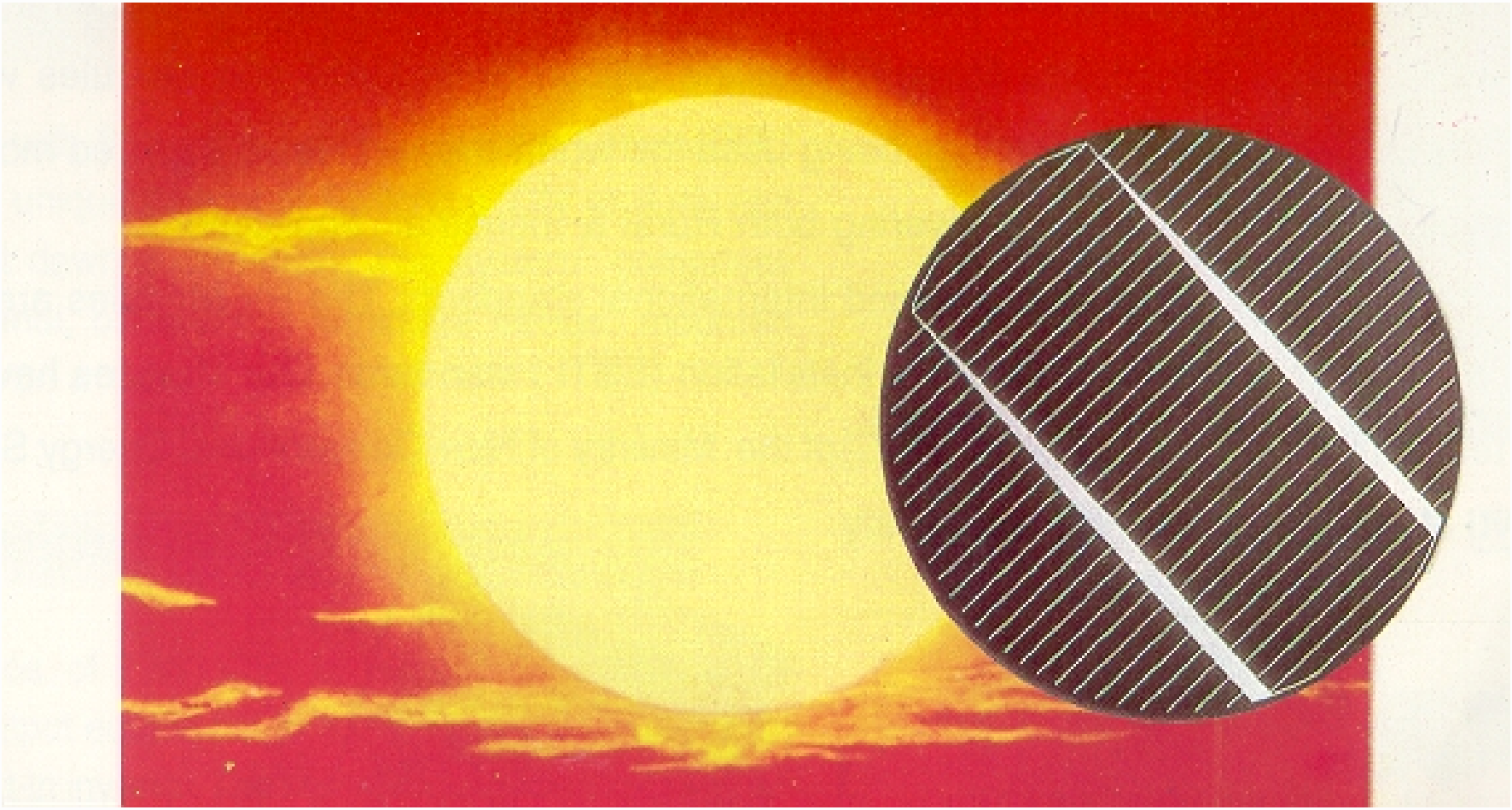
Source: REEEP

Solar Power Applications

Technology type	System	Application
PV (solar electric)	Grid connected	• Supplementing mains supply
PV (solar electric)	Stand-alone	• Small home systems for lighting, radio, TV, etc. • Small commercial/community systems, including health care, schools, etc. • Telecommunications and navigation aids • Water pumping • Commercial systems • Remote settlements • Mini-grid systems
Solar thermal	Connected to existing water and/or space heating system	• Supplementing supply of hot water and/or space heating provided by the electricity grid or gas network
Solar thermal	Stand-alone	• Water heating, i.e. for rural clinics • Drying (often grain or other agricultural products) • Cooking • Distillation • Cooling

Source: REEEP

Solar Photovoltaic Energy



Solar Cells : Technology Options

- Crystalline Silicon solar cells
  - Single, Multi, Ribbon

- Thin Film solar cells
  - Silicon, a-Si, m-Si, CdTe, CIGS

- Concentrating solar cells
  - Si, GaAs

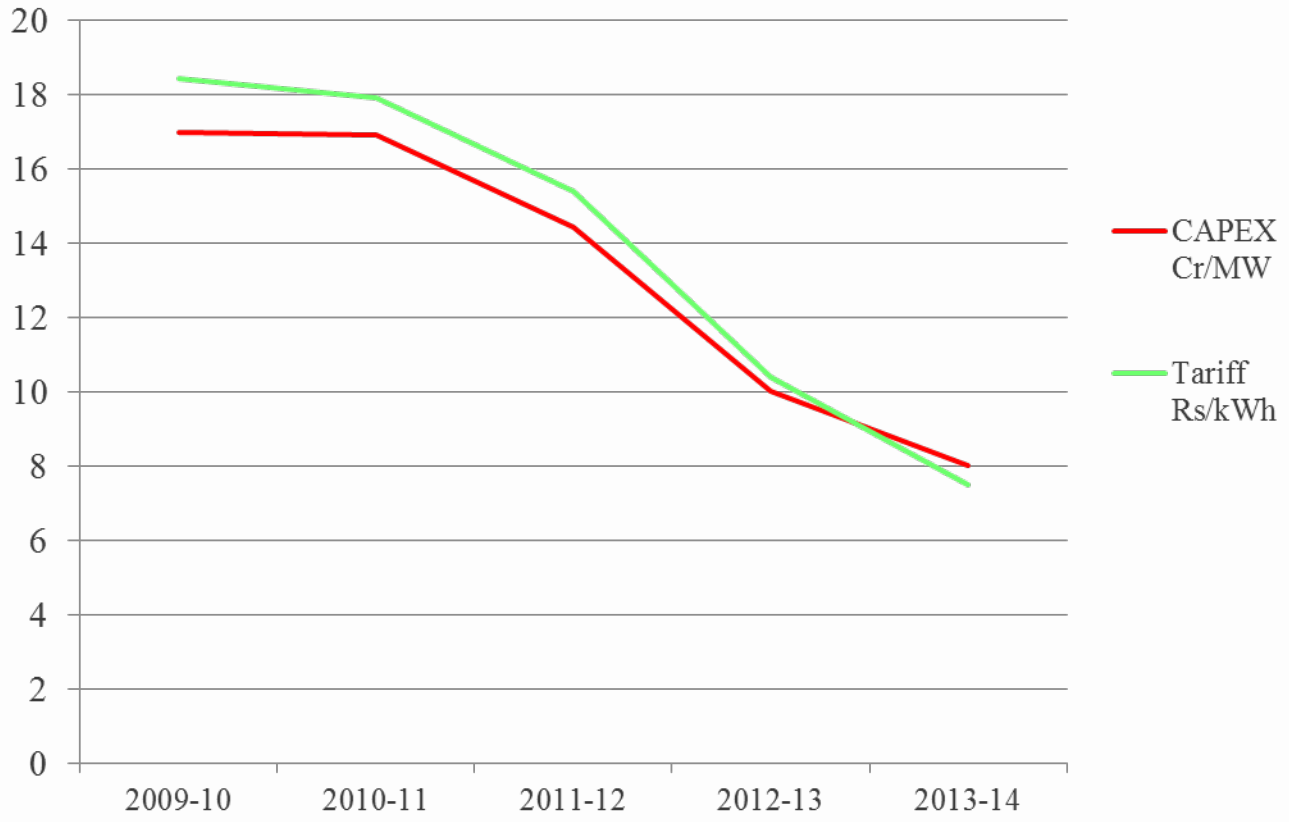
- Dye, Organic, nano materials & other emerging solar cells

Crystalline Silicon Solar Module Efficiency

TYPICAL IN PRODUCTION

	INTERNATIONAL	INDIAN
SINGLE CRYSTAL	15 – 20.4 %	14 – 17 %
MULTI CRYSTAL	13 – 16%	13 – 16%

PV Capital Cost & CERC Tariff Trends



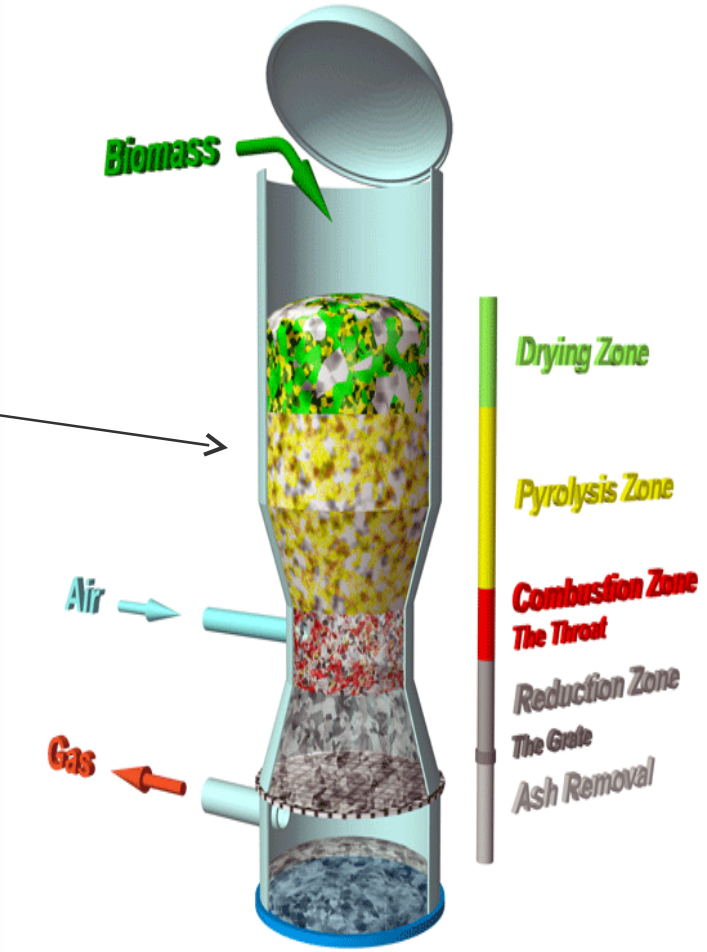
Bioenergy Applications

Fuel state	Application
Biogas	• Supplementing mains supply (grid-connected)
Biogas	• Cooking and lighting (household-scale digesters) • Motive power for small industry and electric needs (with gas engine)
Liquid biofuel	• Transport fuel and mechanical power, particularly for agriculture • Heating and electricity generation • Cooking fuel
Solid biomass	• Cooking and lighting (direct combustion) • Motive power for small industry and electric needs (with electric motor)

Source: REEEP

Biomass : Technology Options

- *Basic Power Generation Options are Combustion and Gasification*
- *Combustion is a well-established technology and is particularly suited at higher power levels*
- *Gasification is more attractive for Distributed Generation up to a few megawatt output*
- *Conversion of solid fuels into combustible gas mixture called producer gas (CO + H2 + CH4)- Involves partial combustion of biomass*



5 X 100 kWe at Sundarbans, West Bengal

Hydropower

- Hydropower is reliable and cost-effective
- Large hydropower schemes hundreds of MWs
- Small hydropower (SHP), rated at less than 25 MW
- Micro and pico hydro from 500 kW to 50W
- Lifetime of 30+ years
- Characteristics:
  - Reliable
  - flexible operation, fast start-up and shut-down

Source: REEEP

Geothermal

- Energy available as heat from the earth
- Usually hot water or steam
- High temperature resources (150°C+) for electricity generation
- Low temperature resources (50-150°C) for direct heating: district heating, industrial processing
- No problems of intermittency

Source: REEEP

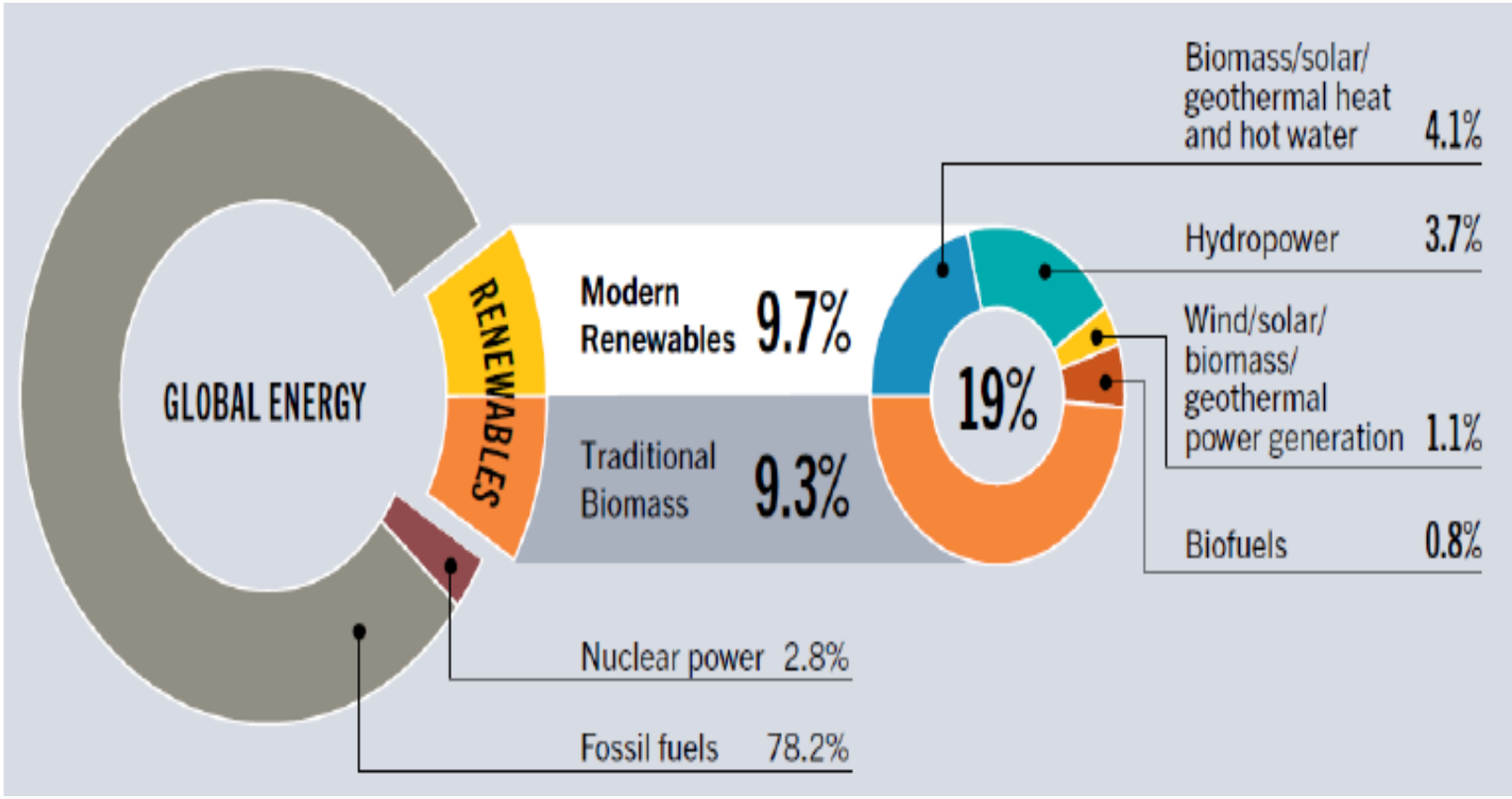
Renewable Energy applications-Summary

RE Technology	Energy Service/Application
Wind – grid-connected & stand-alone turbines, wind pumps	Supplementing mains supply. Power for low-to medium electric power needs. Occasionally mechanical power for agriculture purposes.
PV (solar electric) – grid--connected, stand-alone, pumps	Supplementing mains supply. Power for low electric power needs. Water pumping.
Solar thermal – grid-connected, water heater, cookers, dryers, cooling	Supplementing mains supply. Heating water. Cooking. Drying crops.
Bio energy	Supplementing mains supply. Cooking and lighting, motive power for small industry and electric needs. Transport fuel and mechanical power.
Micro and pico hydro	Low-to-medium electric power needs. Process motive power for small industry.
Geothermal	Grid electricity and large-scale heating.
Village-scale	Mini-grids usually hybrid systems (solar-wind, solar-diesel, wind-diesel, etc.). Small-scale residential and commercial electric power needs.

Source: REEEP

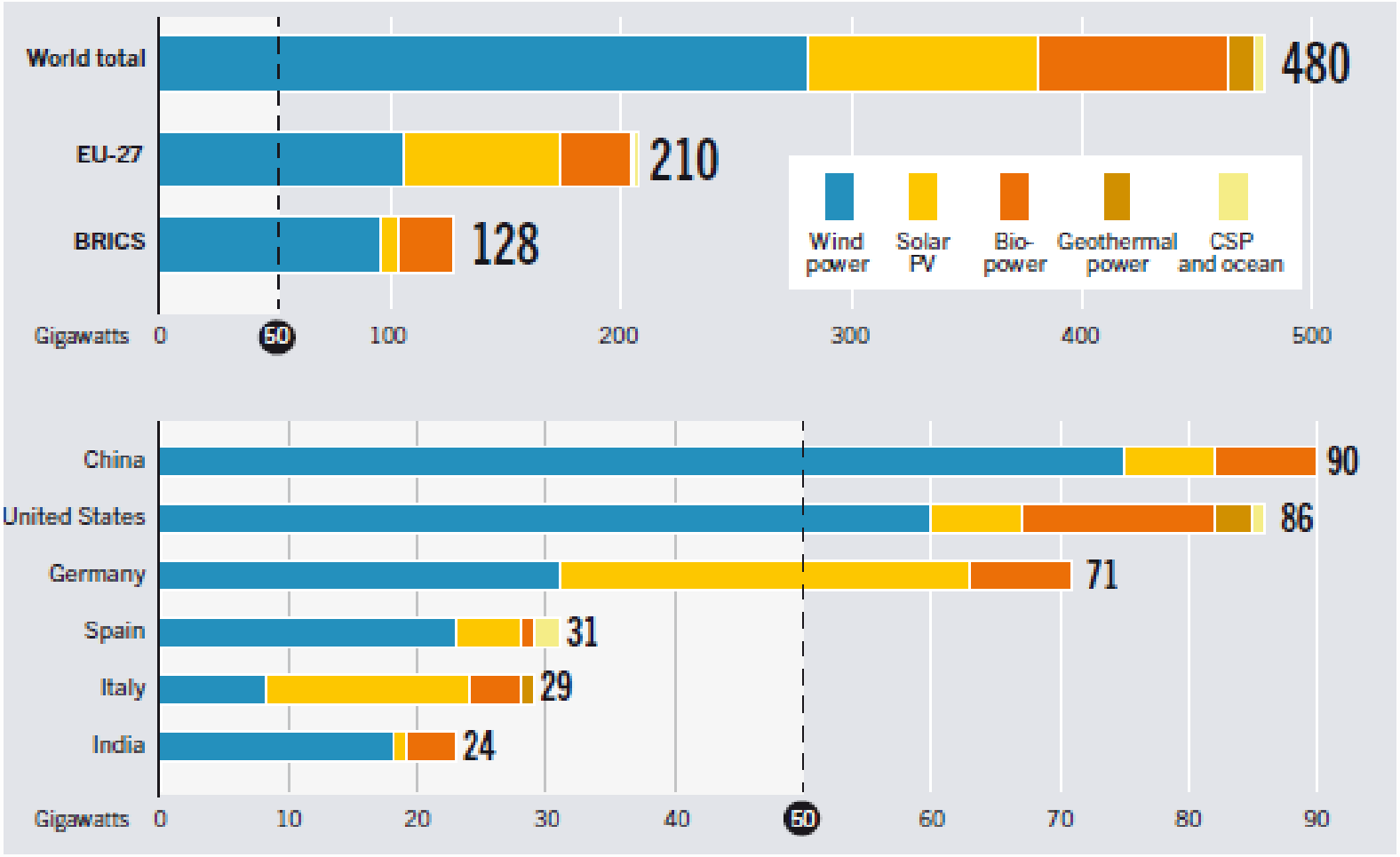
Renewable Energy-Global trends

Renewable energy supplied around 19% of global final energy consumption in 2011



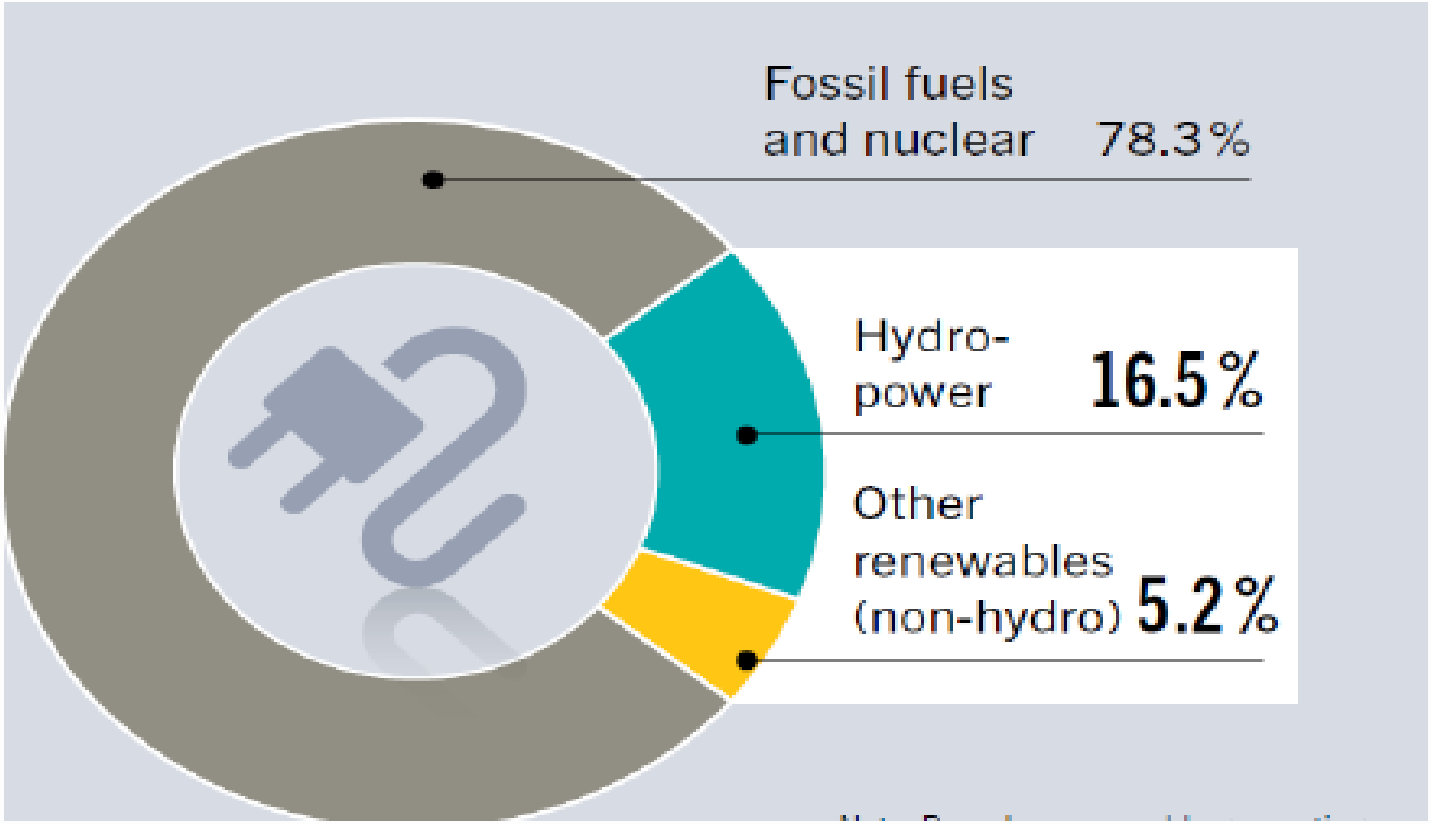
Source: REN 21

Renewable Power Capacity 2012



Source: REN 21

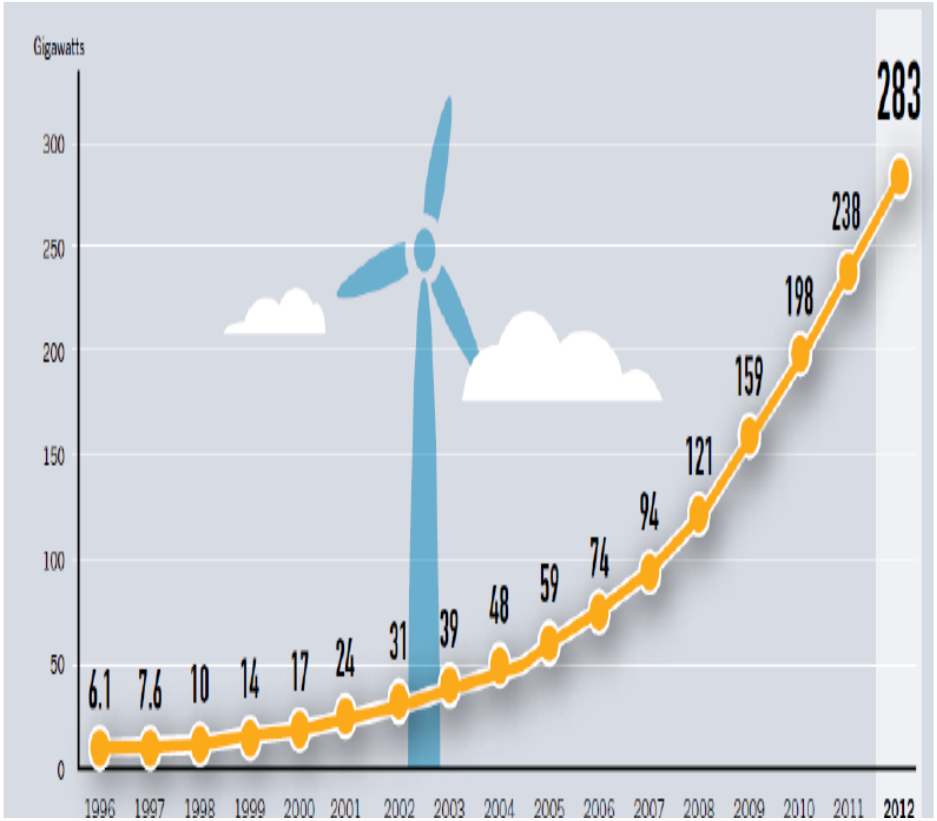
Renewable energy comprises more than 26% of global power generation capacity 2012

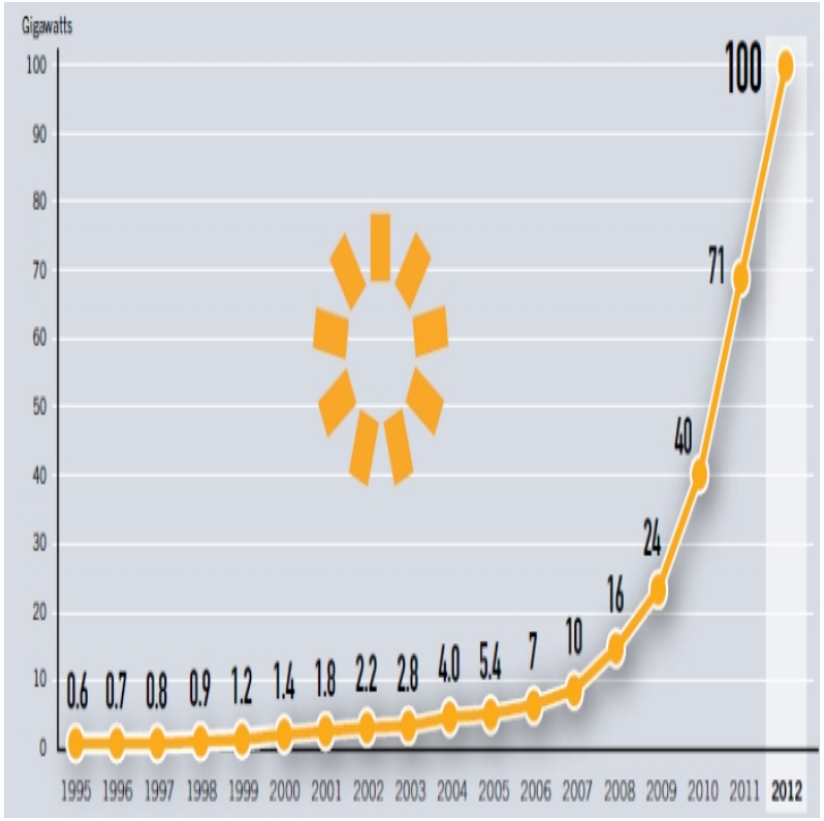


21.7% of global electricity is produced from renewable energy

Source: REN 21

Wind and Solar are the Fastest Growing Sector

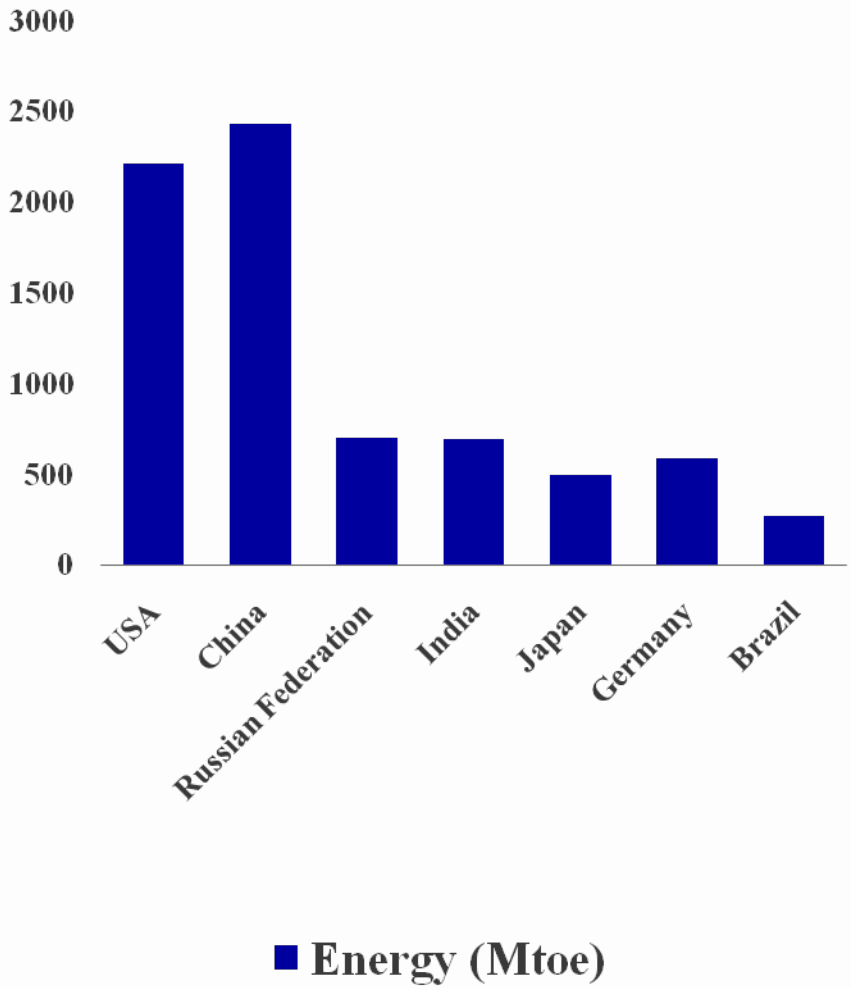


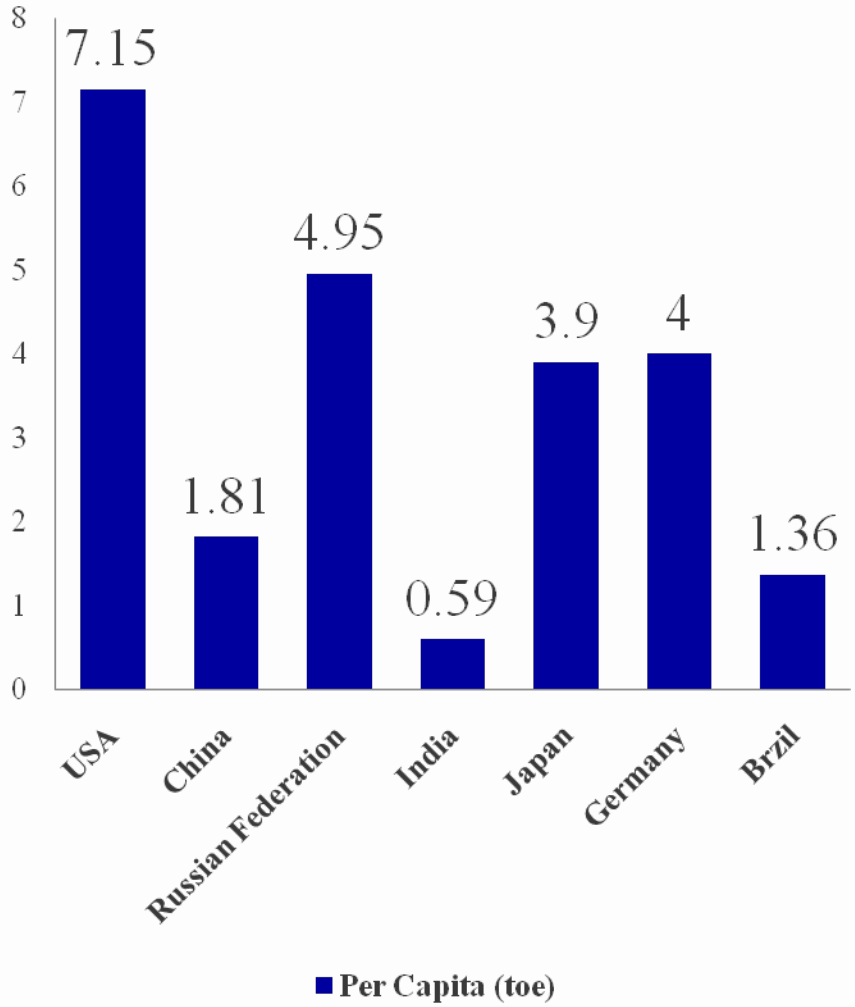


Source: REN 21

Renewable Energy-India context

Where India Stands - Energy Demand (mtoe)





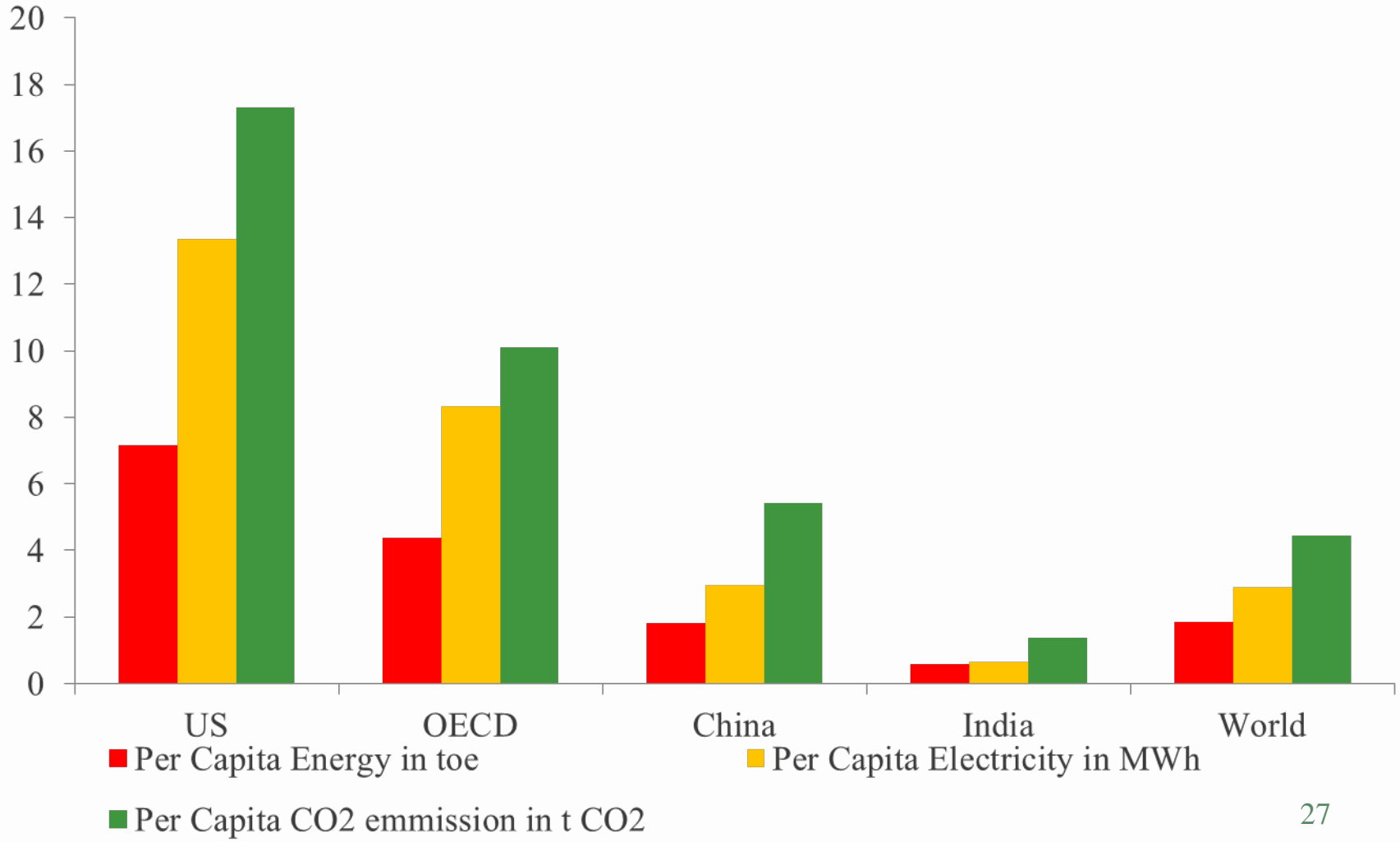
Source:IEA key energy Statistics 2013

Imports - 2031-32

Fuel	Range of Requirement in Scenarios	Assumed Domestic Production	Range of Imports	Import (Percent)
Oil (Mt)	350–486	35	315–451	90–93
Natural Gas (Mtoe)	100–197	100	0-97	0-49
Coal (Mtoe)	632-1022	560	72-462	11-45
Total Commercial Primary Energy	1351-1702	—	387-1,010	29-59

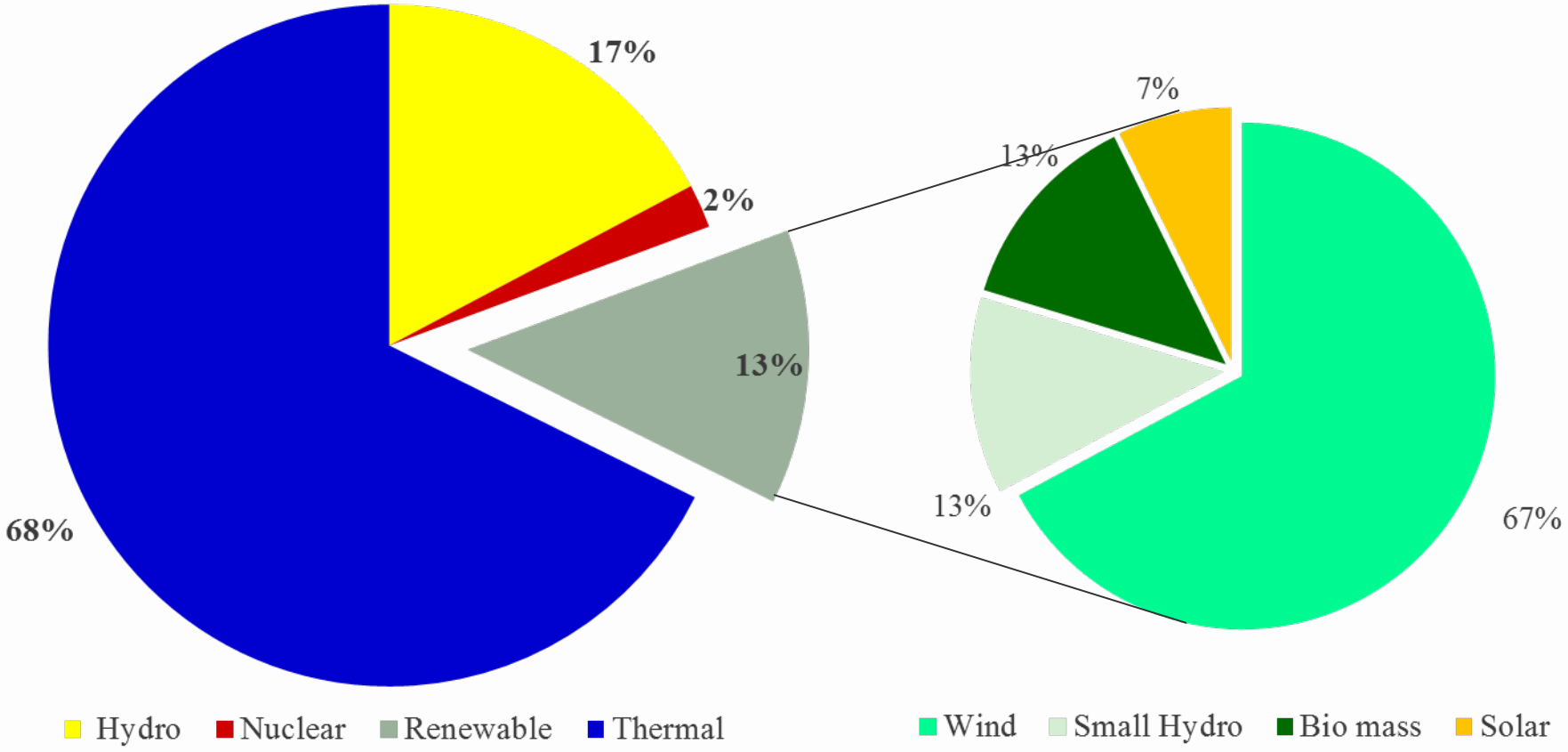
Source: Energy Policy Report, Planning Commission, India

India has very low per capita energy and electricity consumption, and also CO2 emission

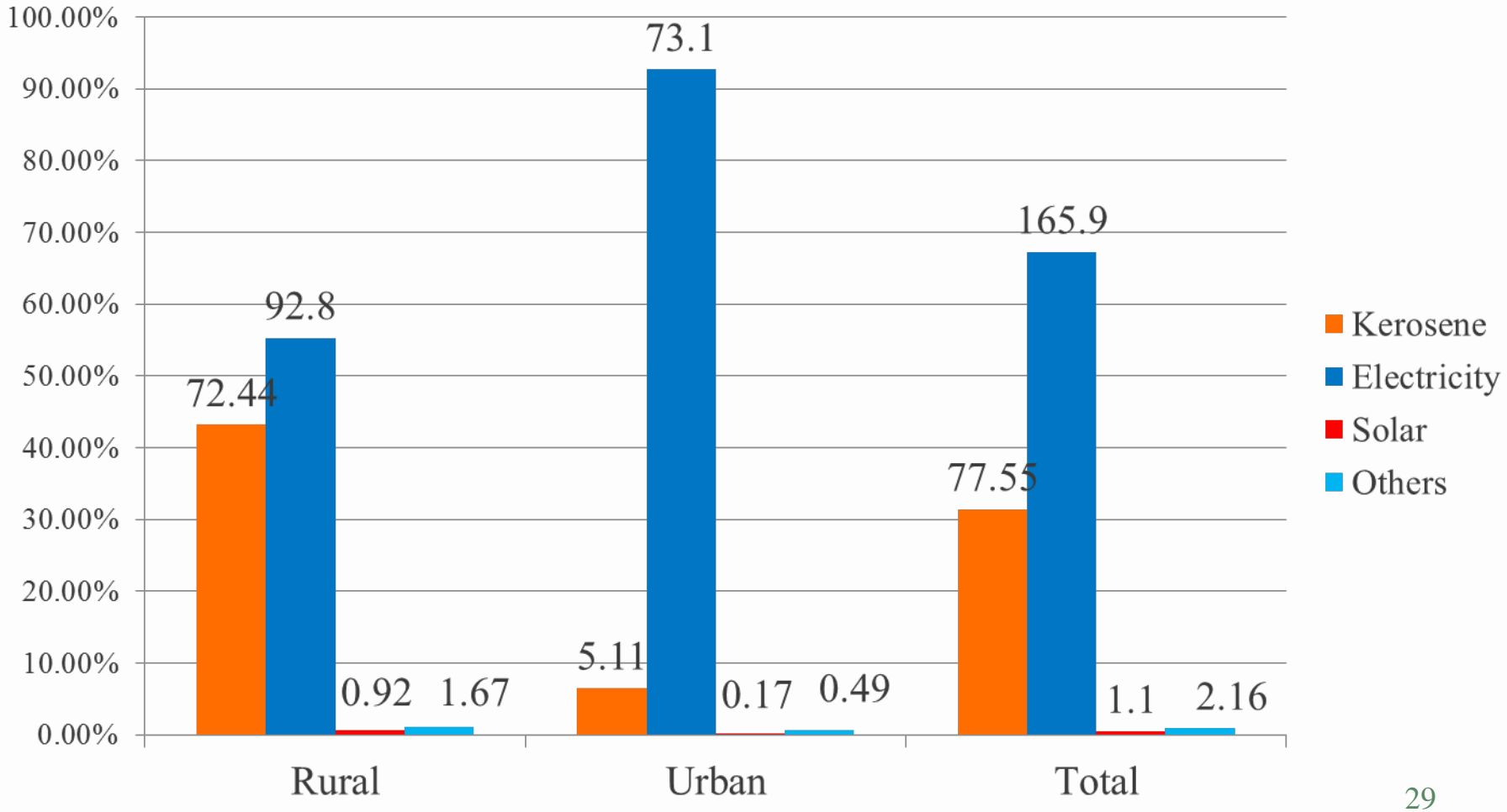


Indian Power Sector : December 2013

- Total installed capacity of 230GW
- India is the world's 5th largest electricity market.
- The current fuel mix is 58% Coal, 10 % Natural gas & Diesel; 17% Hydro; 13% renewable and 2% nuclear.



Households by Main Source of Lighting



Per Capita Emissions and Global Share of Emissions

Country	Per Capita CO_2 emission (in tonnes)	% of global share of CO_2 emissions
Word	4.39	
USA	18.38	19.1
United Kingdom	8.32	1.7
Germany	9.79	2.7
Japan	9.02	3.9
Canada	16.53	1.9
China	4.92	22.2
Brazil	1.9	1.2
South Africa	6.93	1.1
India	1.25	4.8

Source: IEA 2012

India's National GHG Inventories of Anthropogenic Emissions by Sources and Removal for 2007 (in mt)

GHG source and sink categories	CO_2 emissions	CO_2 removals	CH_4	N_2O	CO_2 eq. Emissions
Total (Net) National Emission	1497.03	275.36	20.56	0.239	1727.71
All Energy	992.84		4.27	0.057	1100.06
Industrial Processes	405.86		0.015	0.021	412.55
Agriculture			13.77	0.146	334.40
Land use, Land-use change and Forestry	98.33	275.36			(-)177.03
Waste			2.51	0.016	57.72
Emissions from Bunkers fuels	3.45		0.00003	0.0001	3.48

India after Copenhagen Accord

भारत सरकार
पर्यावरण एवं वन मंत्रालय
GOVERNMENT OF INDIA
MINISTRY OF ENVIRONMENT & FOREST

Executive Secretary
United Nations Framework Convention on Climate Change
P.O. Box 260124,
D-53153, Bonn, Germany
Fax- +49-228-8151997

30 January 2010

Dear Mr Yvo de Boer

I have the honour to communicate to you the information on India's domestic mitigation actions as follows:

India will endeavour to reduce the emissions[1] intensity of its GDP by 20-25% by 2020 in comparison to the 2005 level.

Please note that the proposed domestic actions are voluntary in nature and will not have a legally binding character. Further, these actions will be implemented in accordance with the provisions of the relevant national legislations and policies as well as the principles and provisions of the UNFCCC, particularly its Article 4, paragraph 7.

This Communication is made in accordance with the provisions of Article 12 paragraph 1(b), Article 12 paragraph 4 and Article 10 paragraph 2(a) of the UNFCCC.

Sincerely yours

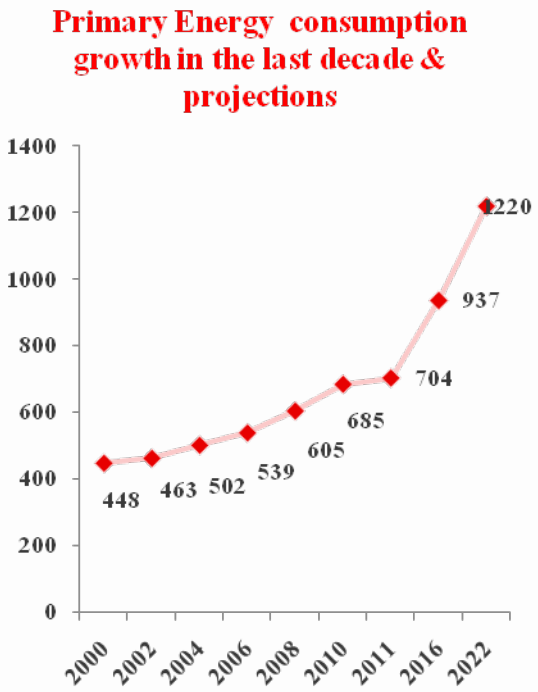
Rajani Ranjan Rashmi
Joint Secretary
Ministry of Environment & Forests
Government of India
(National Focal Point)

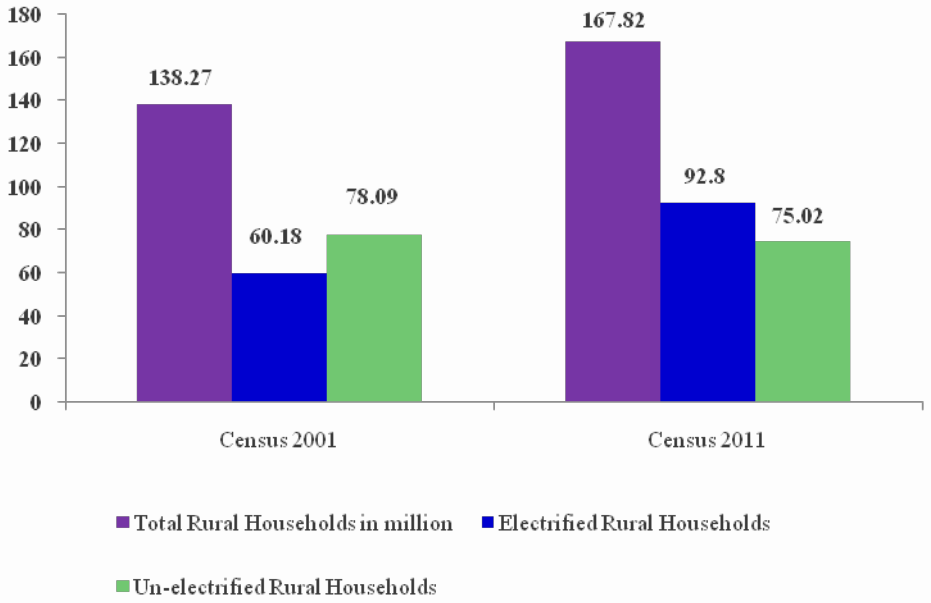
[1] The emissions from agriculture sector will not form part of the assessment of emissions intensity.

जहाँ है हरियाली।
वहाँ है खुशहाली।।

पर्यावरण भवन, सी.जी.ओ. कॉम्पलैक्स, लोदी रोड, नई दिल्ली - 110 003
PARYAVARAN BHAWAN, C.G.O. COMPLEX, LODHI ROAD, NEW DELHI - 110 003

Renewable Energy Drivers





Import dependence for coal – to increase from 17.1% in 2011-12
to 22.4% by the 2016-17 and around 26% by 2021-22

80% oil import by 2016-17- set to further increase

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Renewable Energy in the legal Context

- India has a bicameral parliamentary system - Parliament has supreme law-making powers

- The Concurrent list which contains subjects under the shared purview of the Union and State governments

- Electricity is a concurrent subject (Entry 38 in concurrent list)

- The sub-State level, i.e. Municipal Corporations, Municipalities or Panchayats.

Renewable Energy in India-Timelines

1972 - R&D Activities Initiated By Department of Science and Technology, Government of India

1981 - Commission For Additional Sources of Energy (CASE) Set up as Apex National Policy Making Body

1982 - Separate Department of Non-conventional Energy Sources Set up to Provide Thrust

1987 - Indian Renewable Energy Development Agency, a non banking financing institution was set up

1992 - Full Fledged Ministry of Non- conventional Energy Sources (MNES) Set up

2006 - Ministry Renamed as Ministry of New And Renewable Energy (MNRE)

2009 - Launching of Jawahar Lal Nehru Solar Energy Mission

India has Fairly Large Renewable Energy Potential

Wind

100 GW (at 80 meter hub height)

(A study by C-STEP, Bangalore suggests 100 GW potential could be in Karnataka alone)

- Resource assessment under revision

- Draft Off shore Wind Power Policy released, prel. assessment at 2 locations - 2000 MW, full potential being studied.

Solar Power

50 MW/Sq Km

Area of 60 Km x 60 km waste land could generate electricity that was consumed in India in 2012

Biomass Power

25 GW

From surplus agro biomass, baggase cogen and waste

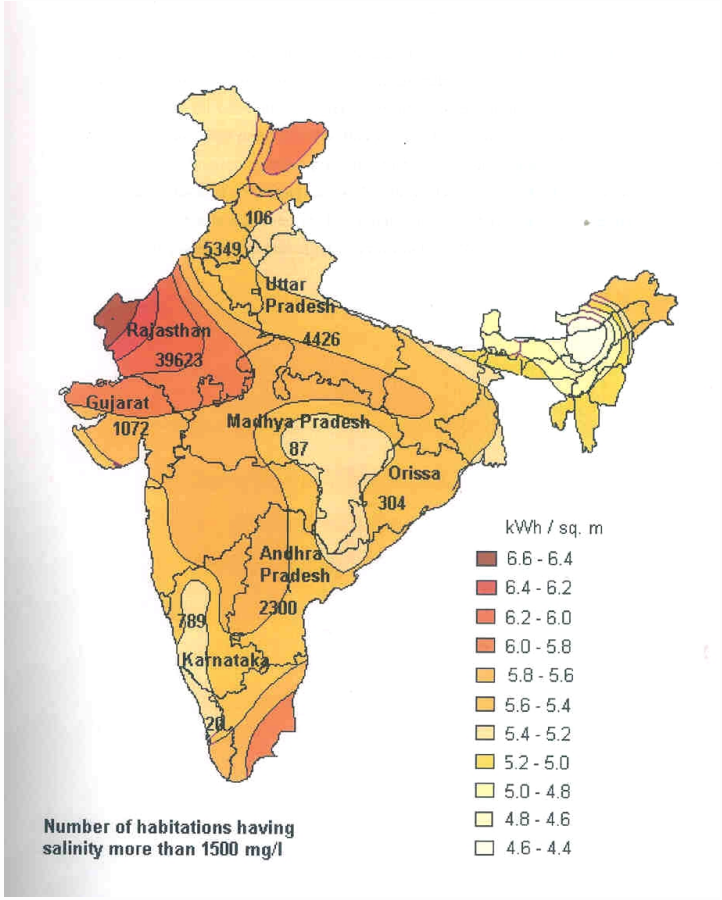
Small Hydro

20GW

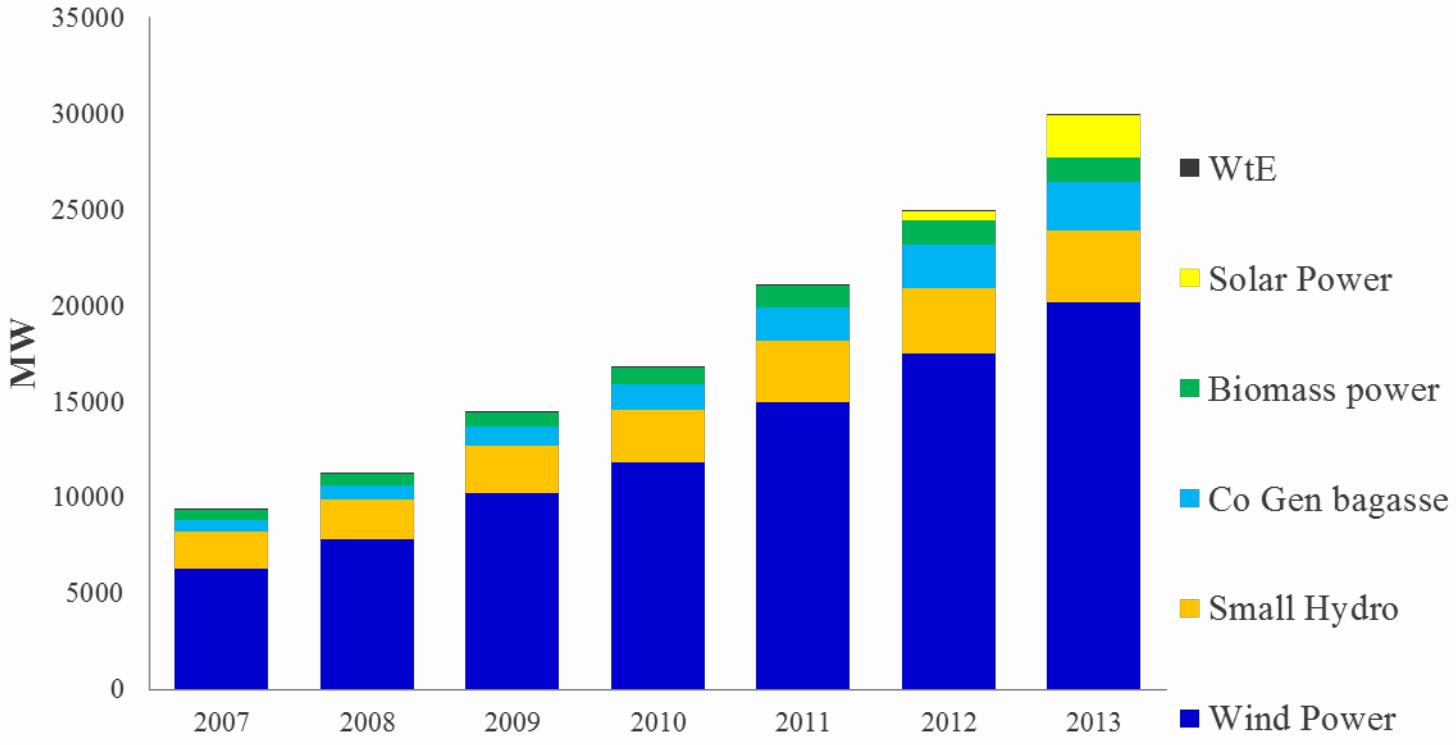
for ≤ 25 MW

Solar Resource Map of India

- Most parts of India receive good solar radiation 4- 7 kWh/sq. m/day
- Possible to meet growing energy demands and cover deficit areas
- Can substantially reduce consumption of kerosene and diesel for lighting and power generation
- Provide access and empowerment at grass root level



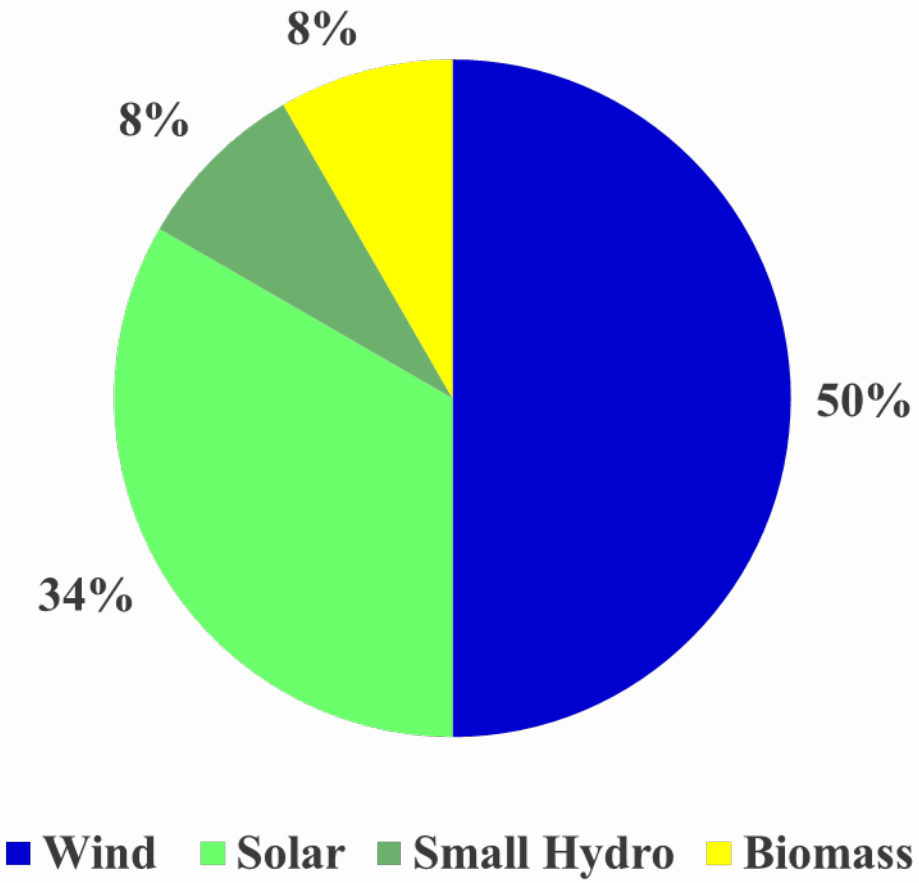
Renewable Energy – Grid Connected



Renewable Energy – Off-Grid and Decentralized Renewables

	Capacity MWe
Waste to Energy	119.63
Biomass(non-bagasse) Cogeneration	509.69
Biomass Gasifiers Rural Industrial	 17.05 141.67
Aero-Genrators/Hybrid systems	2.15
SPV Systems	144.38
Water mills/micro hydel	10.18
	(2547 nos)
Total	944.75
Family Biogas Plants (numbers in million)	47.1
Solar Water Heating – Coll. Areas(million m2)	7.47
Villages Electrified	10,000

Renewable Energy Targets 2012-17



Programme	Targets
Grid-interactive Renewable Power(GW)	30
Off-grid/ Distributed Renewable Power (MWe)	3,400
Decentralized Renewable Power	
Biogas Plants (million)	0.7
Improved Cookstoves (million)	3.5
Solar Thermal Collector Area (mill. sq.m)	6.0

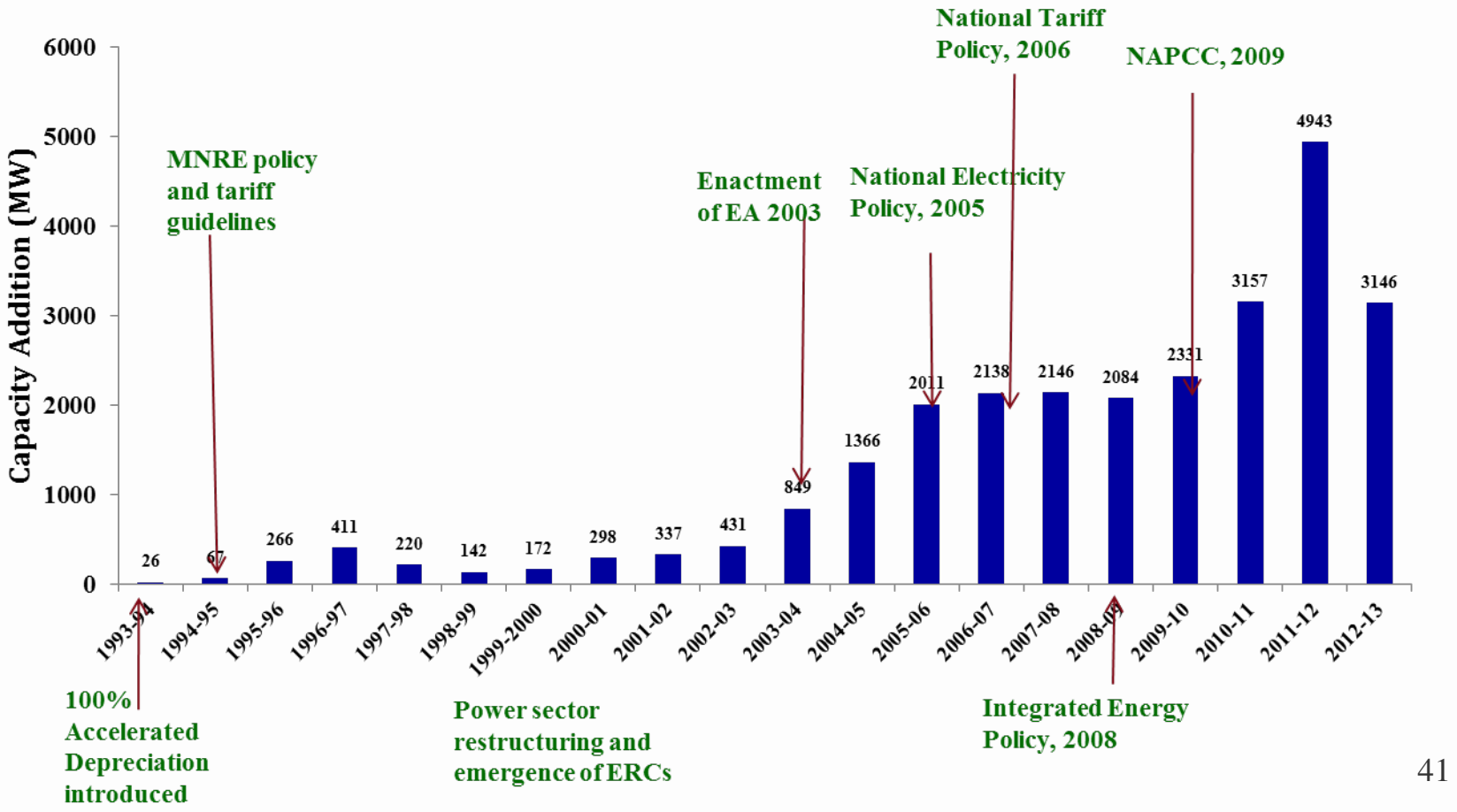
Renewable Power : 30 GW

Growth of Renewables & Regulation

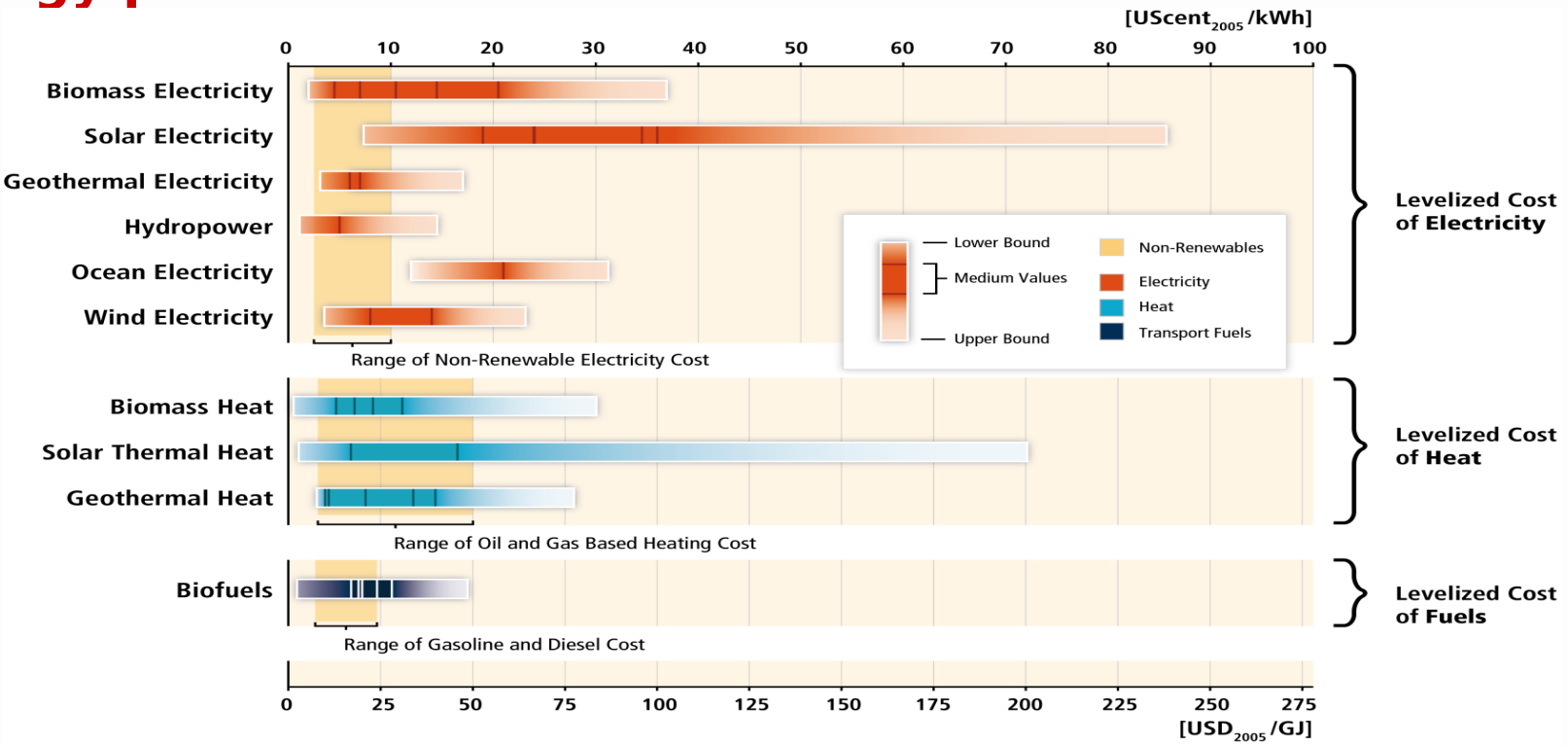
- Renewable Energy development in India has been aided by strong policy and regulatory backing

Preferential Tariffs – SERCs

State Renewable Energy Policies



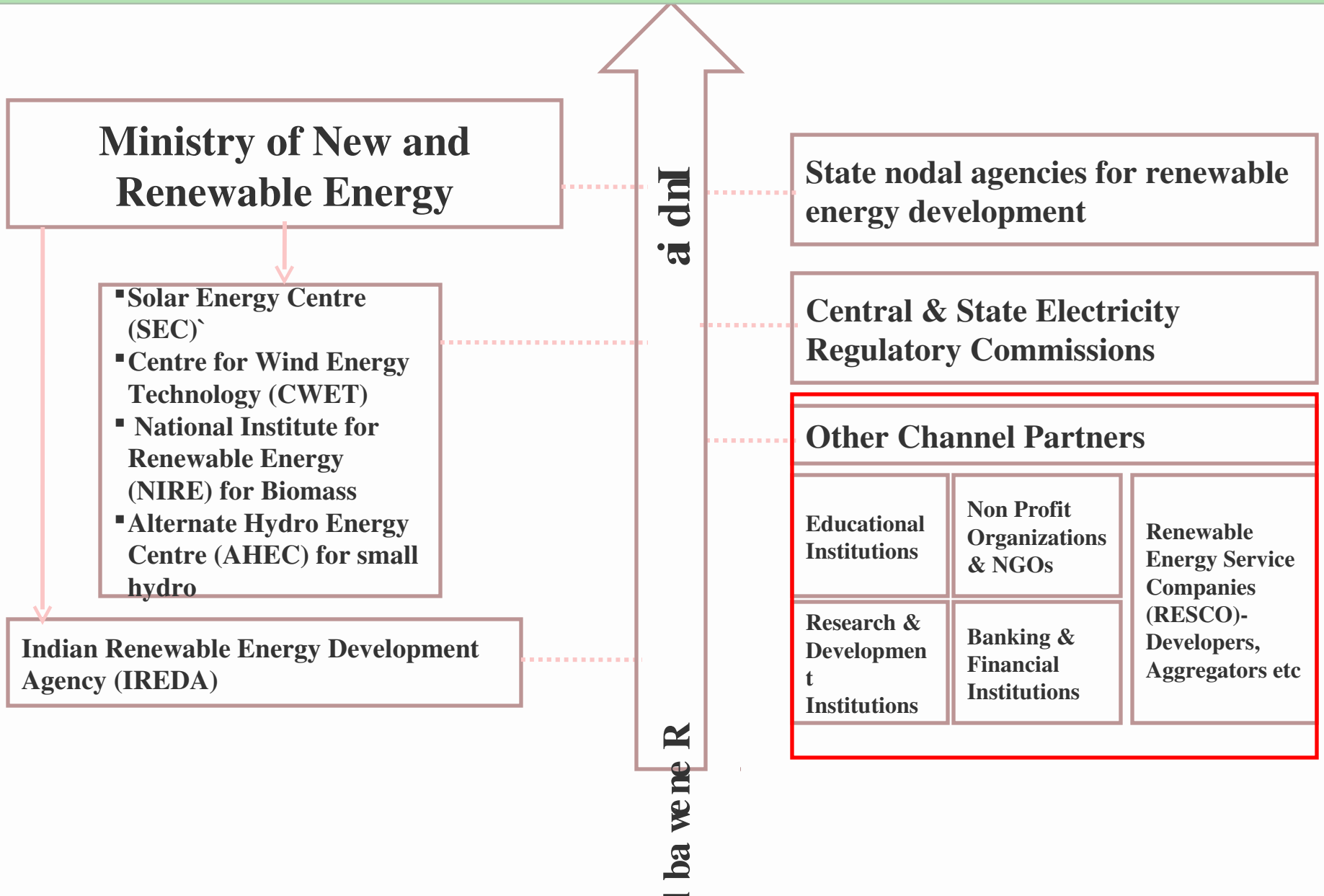
Renewable energy costs are still higher than existing energy prices



Source	**Estimated initial capital cost** (Rs. in crore/ MW)	**Estimated cost of electricity generation(Financial)** (Rs. / kWh)
Small Hydro Power	5.50-7.70	3.54-4.88
Wind Power	5.75	3.73-5.96
Biomass Power	4.0-4.45	5.12-5.83
Bagasse Cogeneration	4.20	4.61-5.73
Solar Power	10.00-13.00	10.39-12.46

Source: IPCC 2011 & CERC 27 March 2012

Institutional Structure



Policy Framework

Electricity Act (EA), 2003

1. Section 86 - promotes RE by ensuring grid connectivity & sale of RE.
2. Section 3 - Central Government to develop a national policy for optimal utilization of resources including RE .
3. SERC's to:
   - Section 86 - fix a minimum percentage energy purchase from RE sources (RPO).
   - Section 61 – determine tariffs for the promotion of RE

National Electricity Policy (NEP), 2005

1. Section 5.2.20 of NEP promotes private participation in RE.
2. Section 5.12.1 of NEP targets capital cost reduction in RE through competition.
3. Section 5.12.2 of NEP states that SERCs should specify appropriate tariffs to promote RE and specify targets for RE.

National Tariff Policy (NTP), 2006

1. A minimum percentage procurement should be made applicable latest by April 1, 2006
2. A preferential tariff to be determined by SERC to enable RET's to compete
3. Procurement of RE by distribution licensee through competitive bidding

2011 Amendment in Tariff Policy :-
0.25% Solar RPO by 2013 and 3% by 2022

Integrated Energy Policy (IEP), 2008

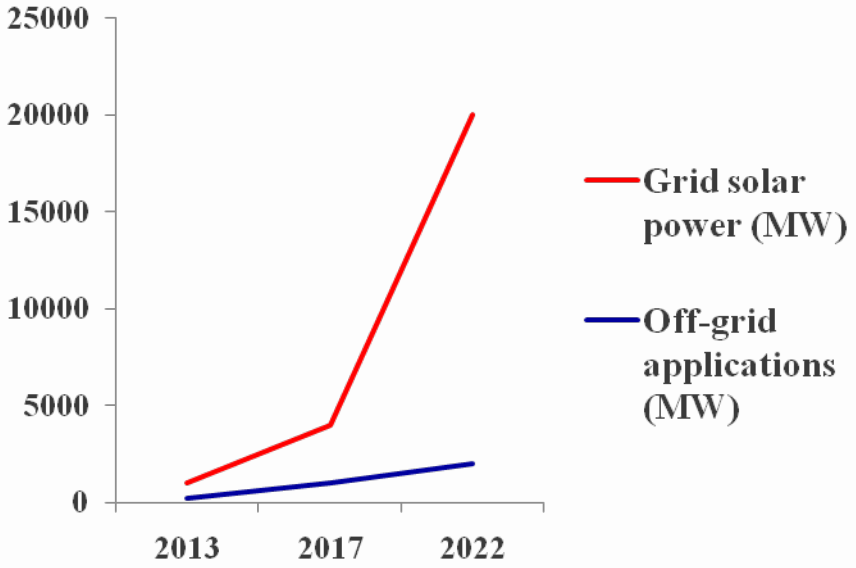
1. Design of incentive structures that are linked to energy generated
2. Regulators to mandate feed-in laws for RE, where appropriate.
3. Environmental subsidy for RE through cess on conventional energy generation
4. FI's should be encouraged to set-up Capital Funds for RE entrepreneurs.
5. Need to auction sites on public property for wind energy development
6. To encourage solar thermal a higher premium of feed-in tariff needs to be provided

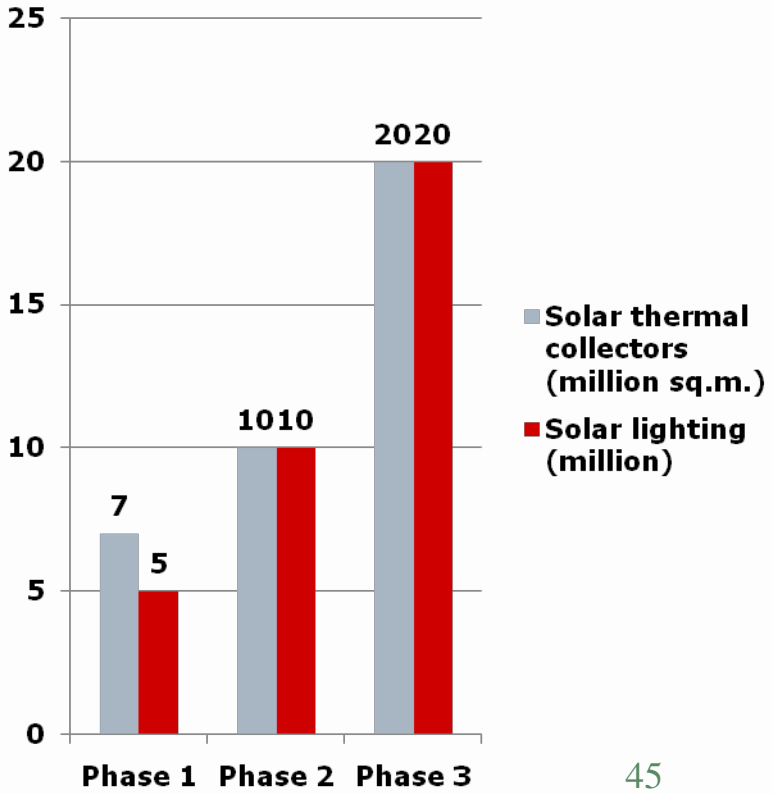
National Action Plan on Climate Change

Paragraph 4.2.2 : Starting 2009-10, Renewable Purchase Obligations be set at 5% of total grids purchase, to increase by 1% each year for 10 years.

lar Energy

Jawaharlal Nehru National Solar Mission was the first Mission launched by the Prime Minister in January, 2010 under National Action Plan on Climate Change and in his view it was its centre piece





In addition, 100 MW capacity distributed small grid connected power plants during Phase -1

5 MWp PV (Crystalline) Grid Power Plant at Khimsar Vllage, Jodhpur, Rajasthan

4.2 MW Wind Farm Project set up in Chitradurga District, Karnataka

Grid-connected Renewable Power
Challenges & Approach

Problems

- Infirm power- how to handle it particularly when volumes are created
- Scheduling/grid interaction – how to maintain grid stability
- Renewable energy is not uniformly distributed- how do we transfer
- Cost on power evacuation infrastructure- how do we support, where from funds
- Issue of pass over- how to share it equitably
- Resource assessment-much more detailed required

Financing renewables

- Cost of funds too high
- Not enough available
- Not enough familiarity
- Instruments need change e.g. risk guarantee fund – longer duration.

Energy Access in India- Renewable Energy Potential/ possibilities

- Renewable energy offers sustainable solutions

- Solar and biomass technologies are most promising technological options, with mini-hydro wherever it is available

- Examples:

- Solar Lighting
  - Through banks
  - Remote Village Electrification Scheme of MNRE

- Rice husk gasifier system for Village Electrification

- Mini/Micro-Hydel based Village Electrification

Kerosene Calculator

10 million households with solar home lighting systems	**Kerosene saved (120 litre/household/year)**	**1200 million litres/annum)**
10 million households with solar lanterns	**Kerosene saved (60 litre/household/year)**	**600 million litres/annum**
Kerosene subsidy over 5 years	**@ Rs 22 /litre kerosene**	**18900 crore**
Total one time subsidy for 20 million solar systems	**@ Rs 6000/solar home lighting system; and @ Rs 2000 / solar lantern**	**8000 crore**

Rice husk gasifier system for Village Electrification

- One 32 kWe rice husk gasifier system provides electricity to about 400 households in one village.
- About 150 villages / Hamlets are benefiting in East and West Champaran, Muzaffarpur, Bihar
- Villagers pay Rs.1.50 to 2.00 per day (Rs.45-60 per month) for 1-2 CFL of 15 Watt
- Saving on kerosene cost – Rs.55 per month (Rs.200 with out subsidy)
- Farmers pay Rs.50/hr from saving of diesel cost used in irrigation pump sets
- Government meet 40% of total cost besides support for training of O&M Technicians, entrepreneurs etc
- Viable Model if demand is 15,000 to 20,000 watt in the village

Solar Home Lighting Systems Through Bank Loans

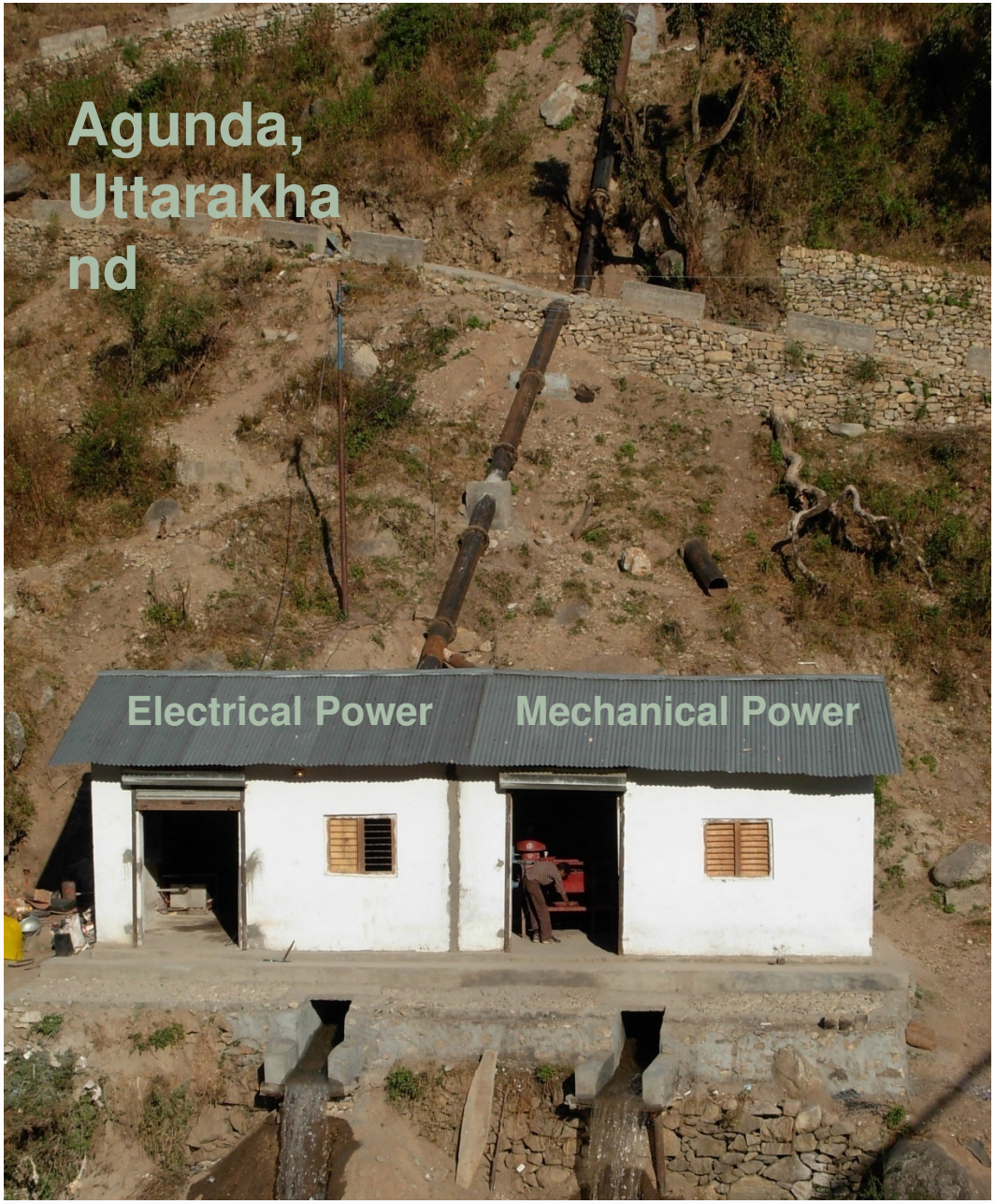
- Funded through a mix of debt and incentives – 20% cost by user
- Financial support – 30% subsidy– Government refinancing banks
- Good response and result in certain states, particularly UP, Haryana, and Karnataka
- The beneficiaries are largely credit worthy individuals
- Capital / Interest Subsidy available through banks

Under National Solar Mission 20 million lighting systems are aimed by 2020

Mini/Micro-Hydel based Village Electrification

- Largely for Himalayan and sub-Himalayan Region
- KW size power generation systems- to caters to cluster of villages
- Average financial support is around Rs 1 lakh/KW
- Serves multiple purpose –lighting and productive activities
- Focus on Community Participation/Cluster Approach

Innovations



Twin shed-Two Turbines

1. Electric Power generation
2. Mechanical Power Generation

Solar Steam Cooking

- Huge amount of LPG/fuel oil being used for cooking in community kitchens of Students Hostels, Ashrams, Industrial canteens, Para-Military forces/Defence establishments etc
- A solar steam cooking system for 500 people can save up to 5000 Kg of LPG/ year
- Over 60 systems of various capacities functioning in country. Largest is at Shirdi for cooking food for 20,000 people everyday
- 1000 systems targeted by 2022 (each for 500 people average) can result in saving of 5 million kg of LPG/year

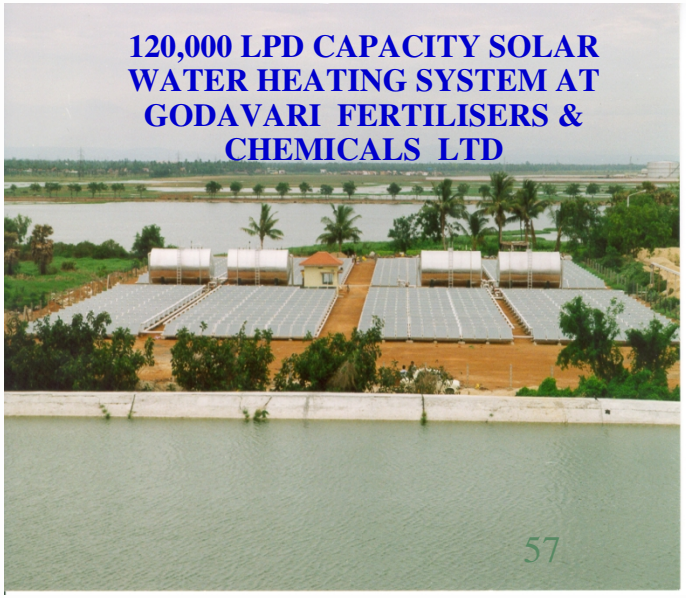
Solar Water Heating

- Hot water at 60-80^{o} C for hotels, hospitals, restaurants, dairies, industry and domestic use

- Apart from residential and commercial sector, Hot water and steam are vital inputs for variety of industries viz pulp and paper, textile, dairy, leather, food processing, electroplating, fertilizer, drug and pharmaceuticalts

- Adoption of 20 million sq meter collector area of Solar water heaters 2020 could avoid over 10,000 GWh of electricity and about 600 million litre of furnace oil


SOLAR HOT WATER SYSTEMS INSTALLED IN PUNE


120,000 LPD CAPACITY SOLAR WATER HEATING SYSTEM AT GODAVARI FERTILISERS & CHEMICALS LTD

Magarpatta City, Pune

Capacity	**2000 kg/day**
Area	**160 Sq.m**
Year	**2005-06**
Cost	**25.25 Lac**
Payback	**3.8 Years**
End Use	**Power Generation and Cooking**

Mainstreaming Renewables

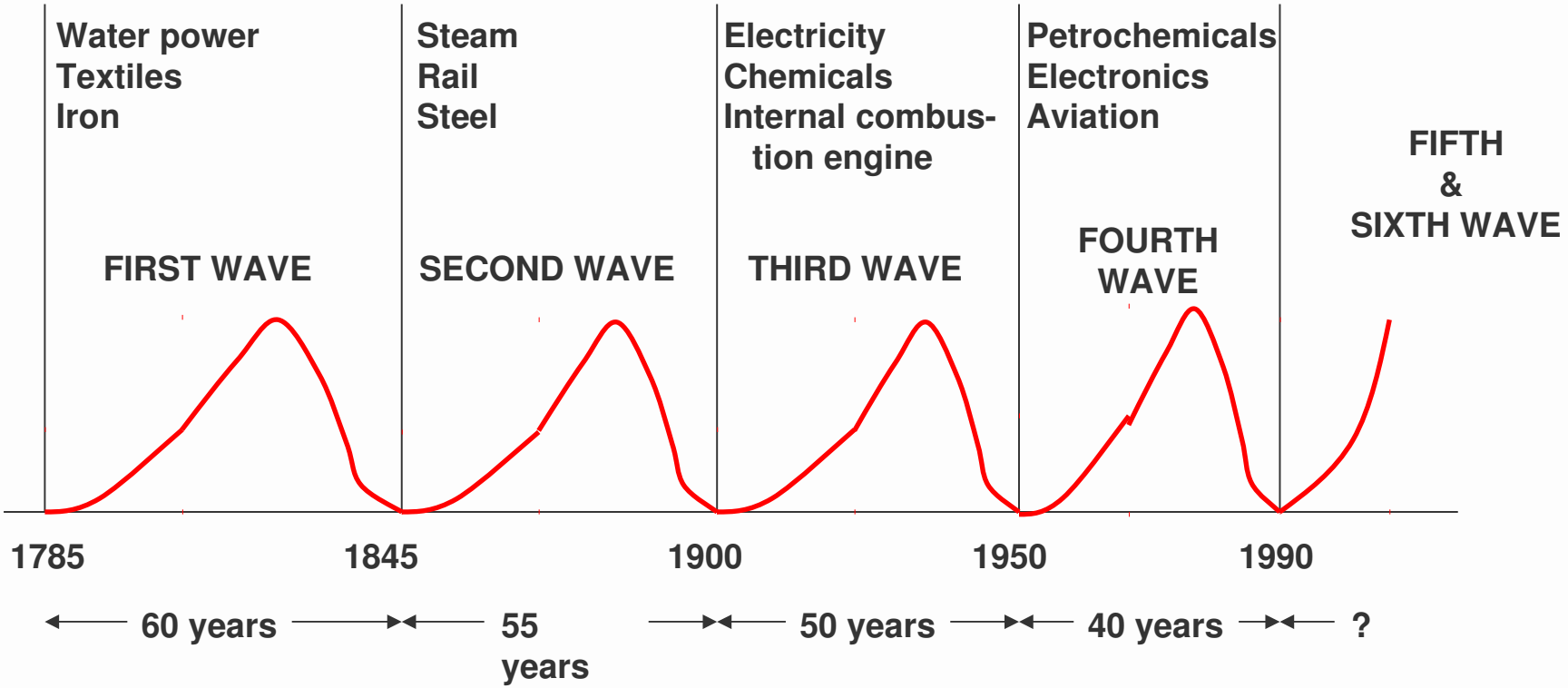
- ***High initial capital costs, financing risks and uncertainties, high transactions costs, technology prejudice, variety of regulatory and institutional factors and subsidies to the conventional forms of energy***

- ***These put renewable energy at an economic, regulatory, and institutional disadvantage relative to other forms of energy supply.***

- ***Affordability is a major challenge alogwith mitigating high risk***

- ***Technology innovation and well designed financial instruments could address some of these***

Schumpeter's Innovation Wave Accelerate



Wave	Innovation
• 5th (1991-2020)	• Digital networks, Biotechnology, Software information technology
• 6th (has already started having overlap with the 5th wave)	• Sustainability, radical resources productivity, Whole system design, Biomimicry, Green Chemistry, Industrial ecology, **Renewable Energy**, Green nanotechnology

Thank You

Renewable Power Potential

S. No.	Resource	Estimated Potential (In MW)
1.	Wind Power	102772
2.	Small Hydro Power (up to 25 MW)	19749
3.	Bio-Power:	
	Agro-Residues	17,536
	Cogeneration - Bagasse	5,000
	Waste to Energy	2554
	Total	147612
4	Solar Energy	>100,000 30-50 MW/ sq. km.