Mainstreaming of RE – The Energy of this Century

at

Indian Institute of Metals
(Delhi Chapter)

Jai Uppal, Sr. Consultant
Renewable & Alternate Energy
B.E.,, M.S.E. (Michigan, USA)
F.I.E.. L.M.I.I.Ch.E., L.M.I.M.A.
jaiuppal @ yahoo.com
(M) +91 9811171121

September 26, 2015

Agenda

- Sustainability & Energy – the Lifeline of Modern Civilization
- Global Energy Scenario
- Global GHGs Scenario
- Present Global Energy & GHG trends & Limits
- Global RE Scenario
- Indian Energy Scenario
- Indian Renewable Energy Scenario
- Cost of Power RE Power
- Global Indicators of Mainstreaming of RE
- Illustrative Indian Load Curve in 2040

Energy - the Life Line of Modern Civilization

- **UN Sustainability Development Summit (2015) – Sept 25 -27, 2015**
- **Energy essential** for our well being & for our civilization
- **Energy plays a vital role in every aspect of life** - Agriculture, Industry, Services, health, education, transportation, homes, offices
- **Correlation** between **degree of development (GDP per capita) and use of Energy (Power per capita)**
- **But dilemma conventional fossil sources are limited/finite & Cause Global Warming, Pollution**

Per Capita Electricity Consumption

Country	Power Consumption (kWh/PC)
China	3,298
Germany	7,081
India	819/1050
Japan	7,847
Sweden	14,030
United States	13,246
World Average	3064

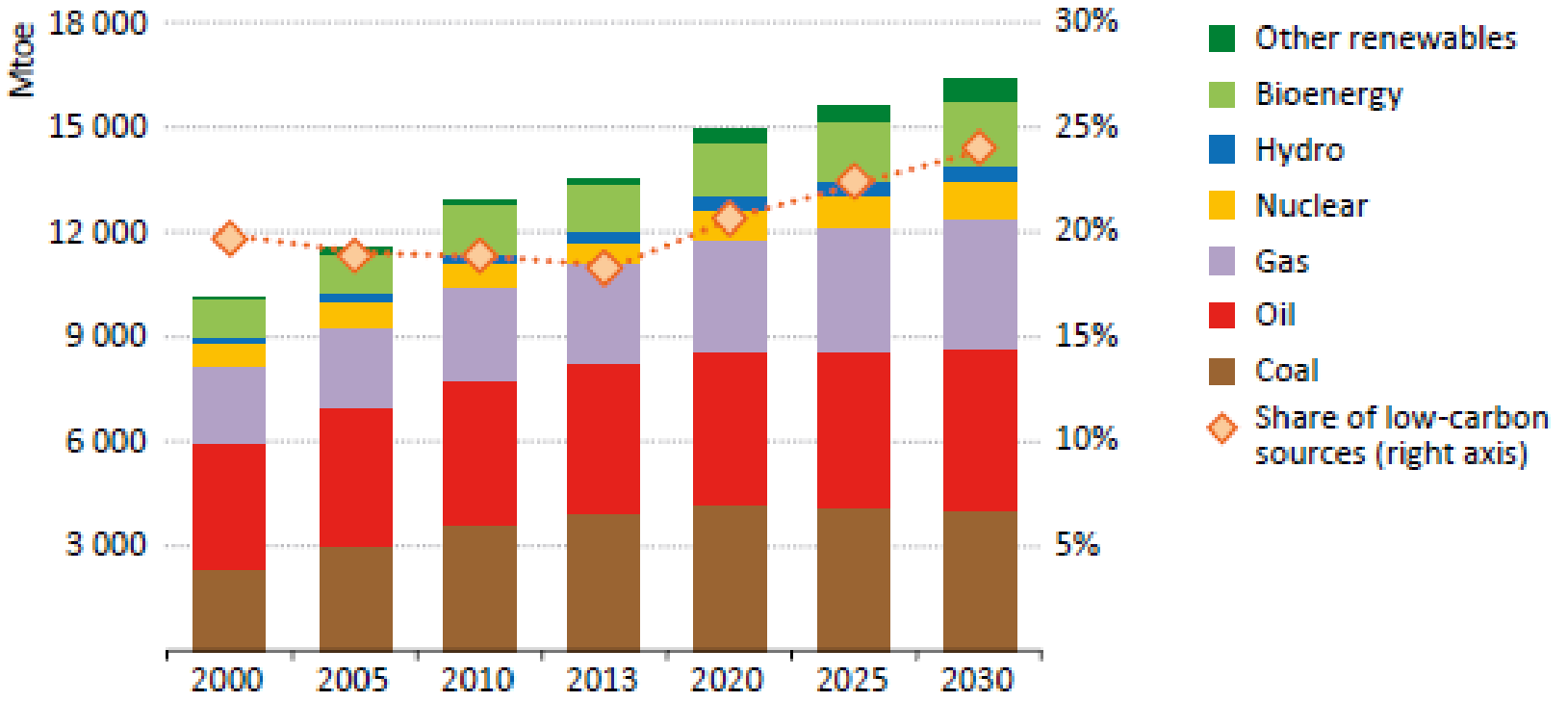
Sources of Energy

- **Prime Fossil sources for Electricity, Heating/Thermal Energy : –**
  - **Crude Oil, Natural Gas, Shale**
  - **Coal/CBM**
  - **(Nuclear)**
- **Renewable Energy:–**
  - **Solar**
  - **Wind**
  - **Hydro**
  - **Biomass/Bioenergy/Biofuels- Solid, Liquid & Gases**
  - Geothermal, Wave, Tide etc**.**

Global Primary Energy Sources (MTOe)

	2013	2030	CAGR (%)
Coal	3973	3448	-0.8
Oil	4235	4313	0.1
Gas	2880	3547	1.2
Nuclear	646	1044	2.9
Hydro	320	482	2.4
Bioenergy	1366	1827	1.7
Other RE	159	708	9.2
Total	13579	15370	0.7

Global Energy Demand by Type



Note: "Other renewables" includes wind, solar (photovoltaic and concentrating solar power), geothermal, and marine.

Global Energy Sectoral Consumption (MTOe)

- **Energy for Power generation – 5173**
- **Sectors in which energy consumed:**
  - **Industry – 2654**
  - **Transport - 2535**
  - **Building – 2987**
  - **Others - 919**
  - **Total Final Consumption – 9095**
  - **Huge consumption – Rapid growth in GHG concentration in atmosphere**

Impact of GHG Global Warming

- **Significant Weather, environmental and social impacts**
- **Physical: –**
  - **Temp rise & rise of sea level, melting of glacier and arctic & Antarctic**
- **Weather - unpredictable & extreme events: –**
  - **more Rain, prolonged droughts, cyclones & tornadoes, temperatures**
- **Environmental: –**
  - **Oceans Marine vegetation & Life, acidification, oxygen depletion**

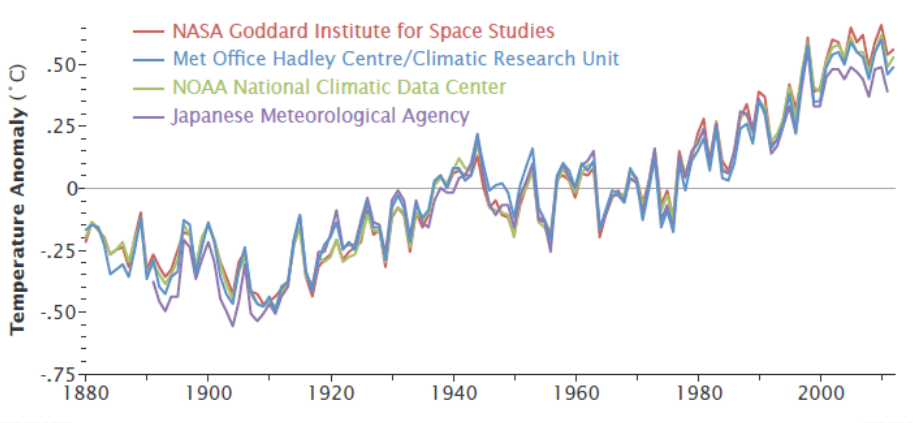
Impact of GHG Global Warming

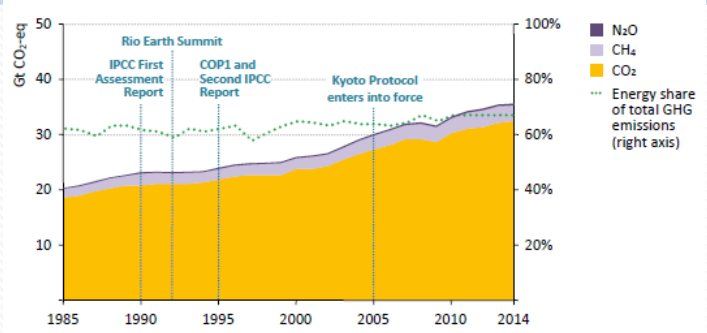
- Forests, crops, food production, Forest fires
- Biological diversity threatened – Extinction of many species,

- **Social –**
  - Health, epidemics, new diseases, deaths. Agri, Forests, Food security, Water availability, Migration of population etc
- **Doomsday scenario - methane hydrates in Ocean beds & permafrost is released**
- **Therefore, Max Limit of 2°C rise to avoid disaster by limiting GHG emissions concentration to 450**

Global GHGs Scenario & Trends

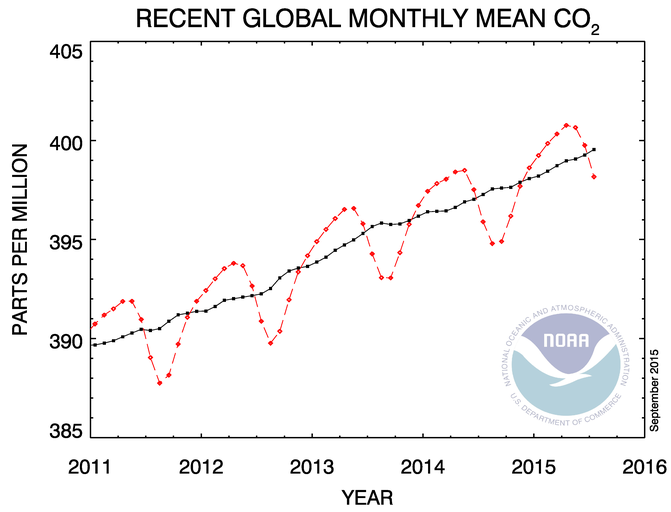
	Total CO2 (GT)	Per Capita CO2 (T)	Of World Total (%)
China	10.3	7.4	29
USA	5.30	16.6	15
EU	3.74	7.3	10.6
India	2.07	1.7	5.9
World	35.27	4.97	100



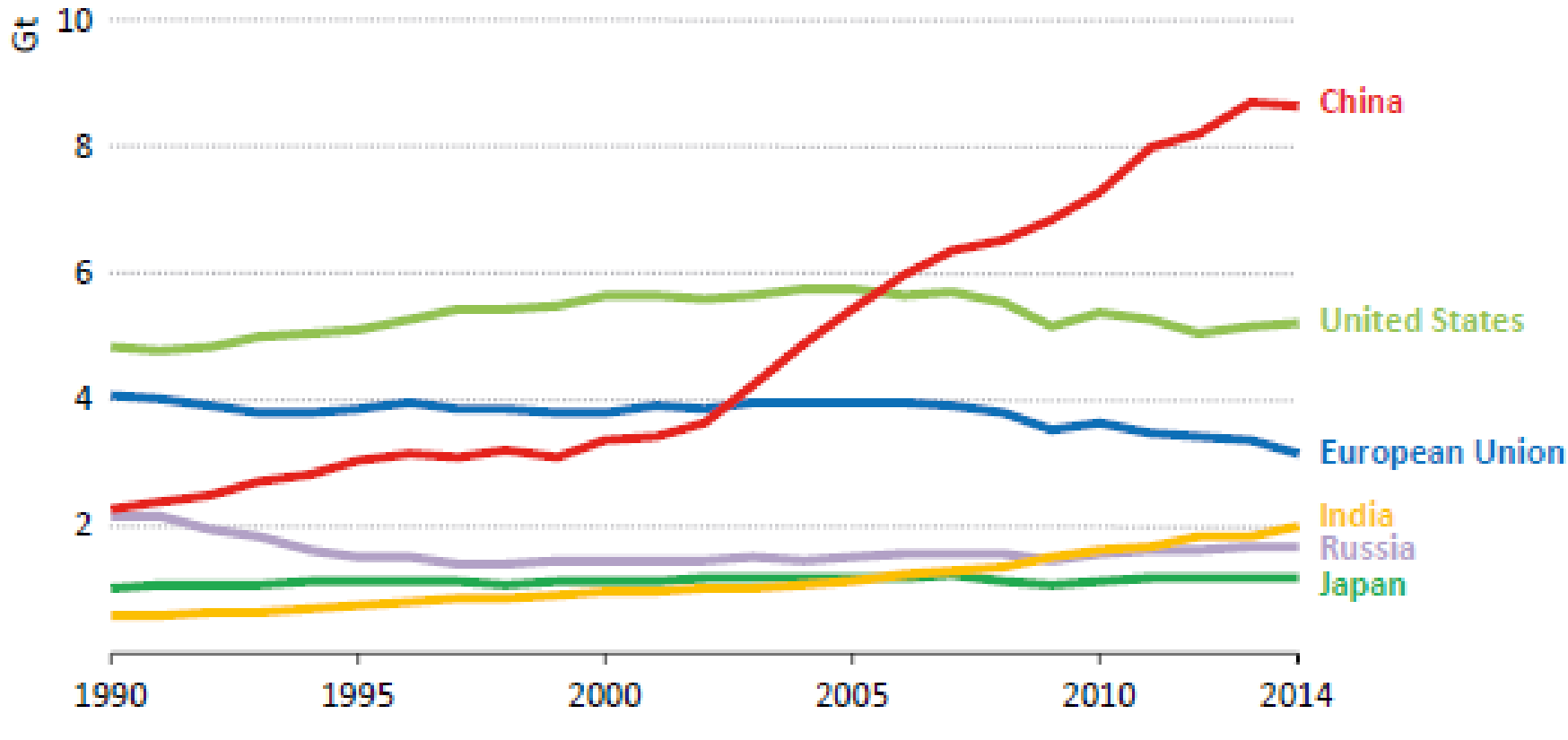


Notes: CO_2 = carbon dioxide, CH_4 = methane, N_2O = nitrous oxide. CH_4 has a global warming potential of 28 to 30 time: that of CO_2, while the global warming potential of N_2O is 265 higher than that of CO_2.

Sources: IEA and EC/PBL (2014).



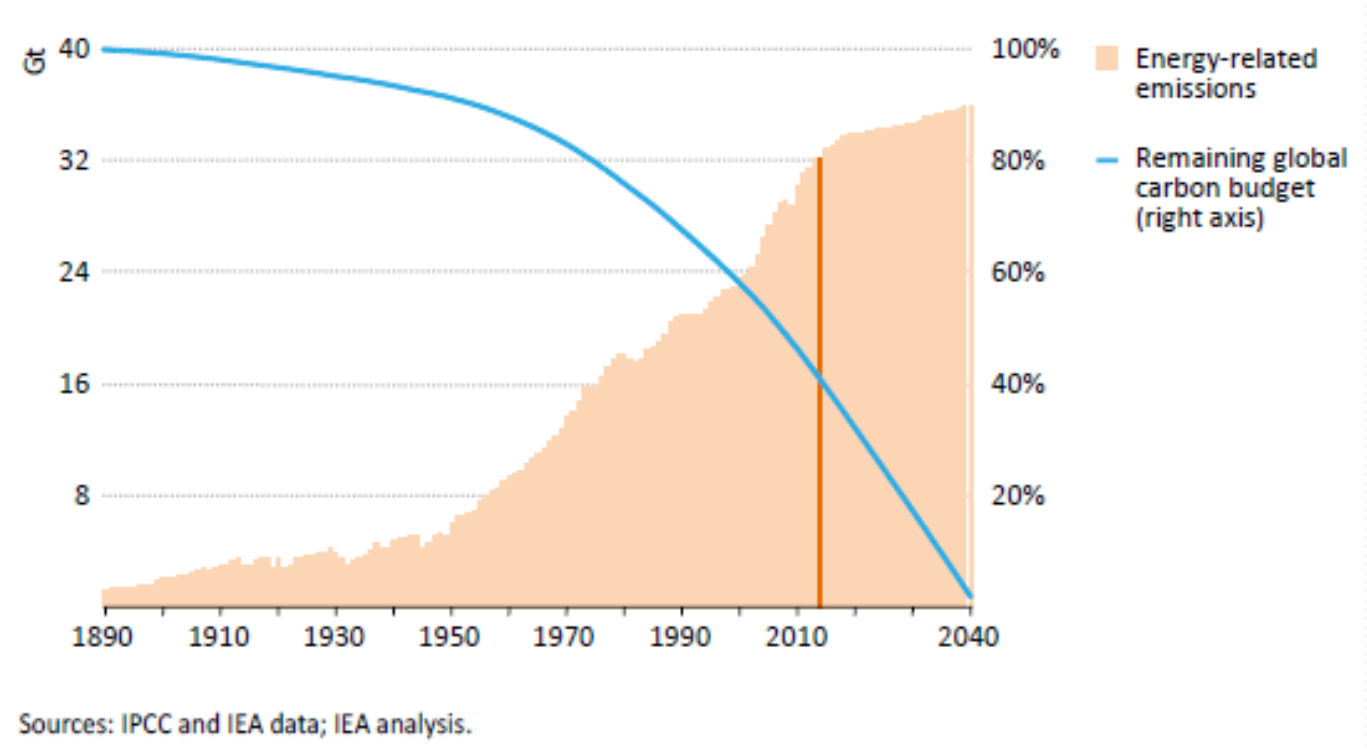
Trends in CO2 Emissions



Present Global Energy & GHG Trends & Limits

- **Prices of Crude oil - from +$100/BBL to ~$50/BBL,**
- **Natural Gas <$4/mBTU**
- **International Coal prices are down to ~$53 /T**
- **Increase of consumption may take place due low prices & as world economy picks up**
- **Threat from Global warming: -**
- **This will require a max cumulative CO2 budget of ~3000 GT**
- **Of which 1970 GT has already been emitted before 2014**
- Therefore, **Total Budget available for future ~ <1000 GT while We are spending around 35 GT annually**

Global Energy Related CO2 Emissions Budget to Limit 2° C Rise

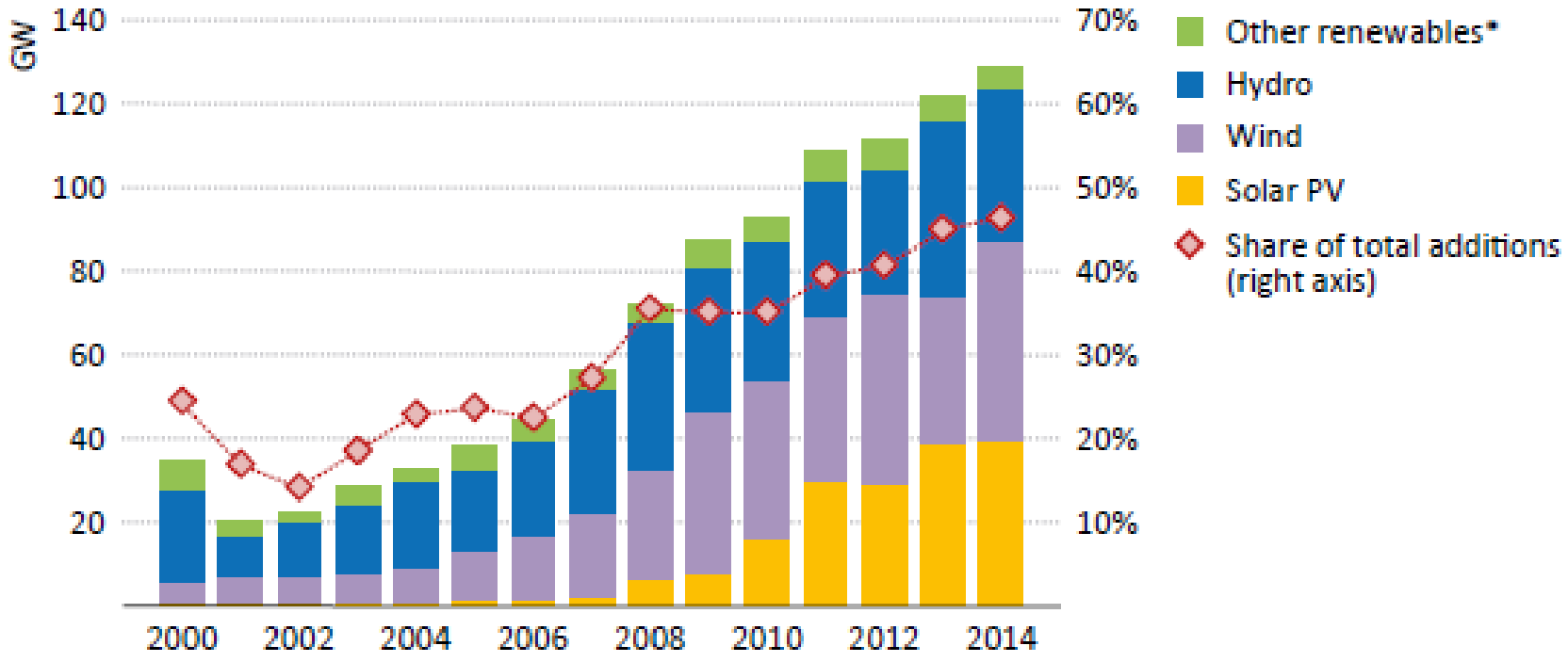


2010 Target to limit the rise of Global temperature to 2 deg C by limiting the CO2 level to 450 ppm – present 399 ppm

Role of Renewable Energy

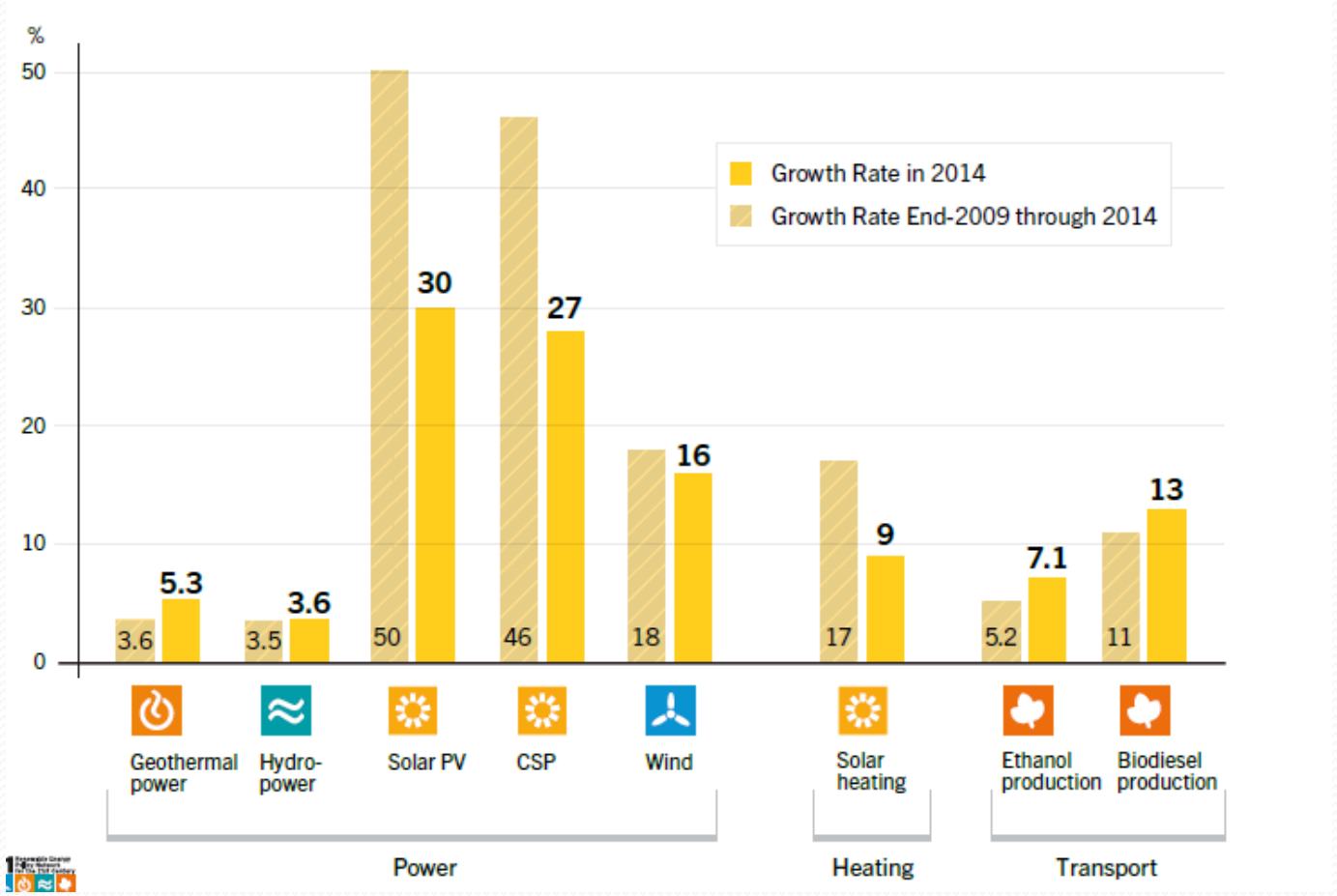
- **Good News of 2014:**
  - **Global economy grew by ~3% but energy related CO2 emissions flat – 1st time**
  - **RE ~50%of all additional installed power capacity**
- **The Pledges:**
  - **EU' to cut GHG emissions by at least 40% by 2030 (from 1990)**
  - **USA to cut GHG emissions by 26% to 28% by 2025**
- **Increasing *energy efficiency all sectors***
- **Rapid rise in investment in RE *to* $270 billion in 2014**

Global Additional Installed Capacity of RE

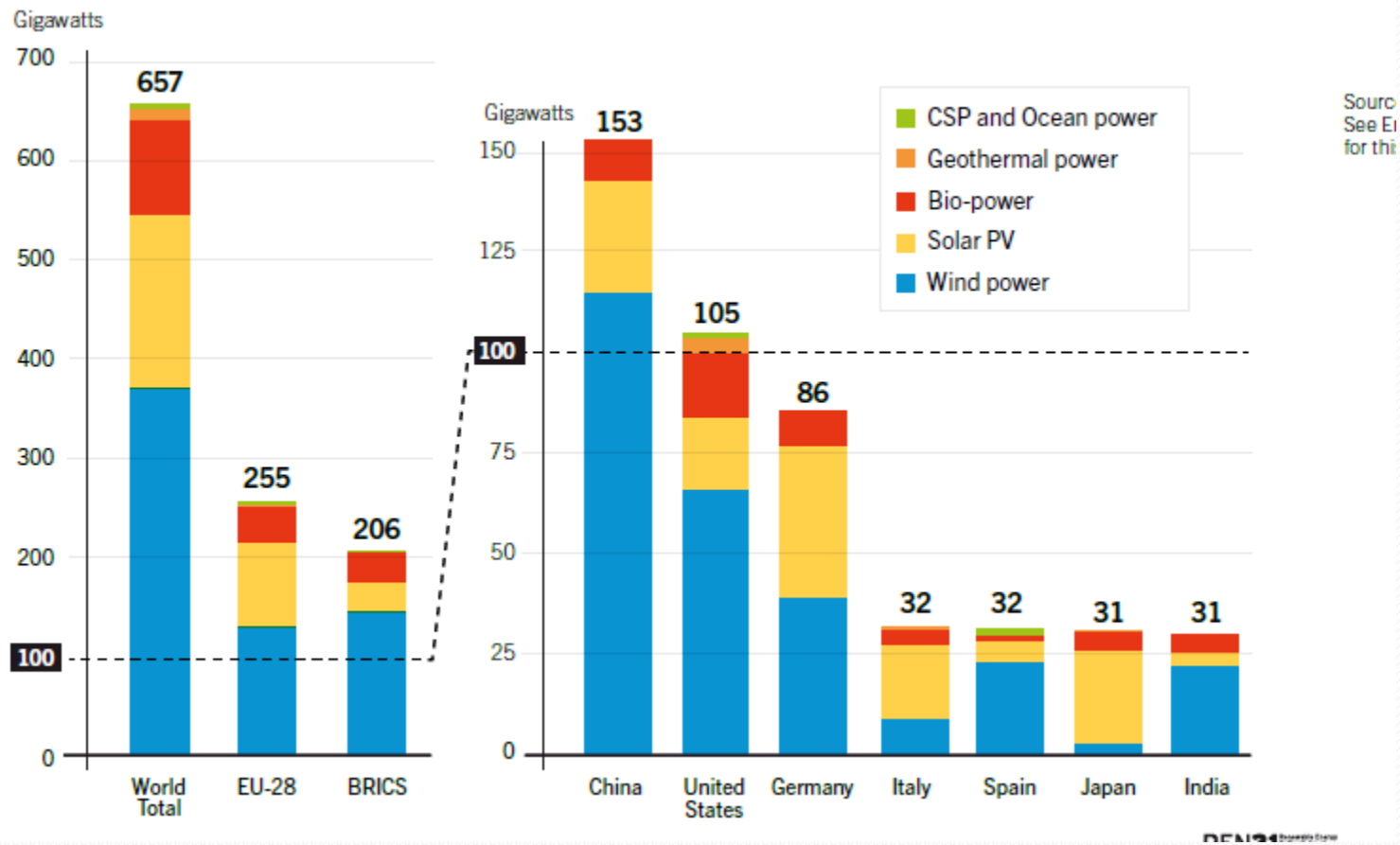


* Includes geothermal, marine, bioenergy and concentrating solar power.

RE Sectoral Growth Rates



Total Installed RE Capacity (w/o Hydro)



RE Role & Country Wise Ranking

- **Global Energy Consumption:**
  - **Fossil – 78%, RE – 19% ,Nuclear – 3%**
- **RE – 58.5% net addition Global Power capacity in 2014**
- **27.7% of total installed power capacity**
- **New investment – US$ 270 B**
- **Total RE Power capacity: 1,712 GW; 657GW (w/o hydro)**
- **Total Power Capacity (w/o hydro) ranking China, USA, Germany (Brazil), Spain/Italy (Germany), Japan/India (Canada),**
- **Biopower – USA**
- **Hydro – China**
- **SPV – Germany, CSP – Spain**
- **Wind – China (India 5th)**

Indian Energy Consumption

Type of Energy Consumption	Units	(1950)	(2014) (Domestic +Imports)	R/P
Coal & Lignite	Mill T	32.3	620 +150	100
Crude Oil	Mill T	0.27/3.4	38+190	20
IC Power (Hydro+N+RE)	GW	2.3 (0.6)	285 (40+4.8+37)	NA
Power Generation	BU	6.6	1049	NA

Indian Energy Trends

- **Imports of fossil fuels are rising**
- **Not enough Energy Reserves on a long term basis – India's Energy Security & National security is threatened**
- **India:**
  - **Third largest emitter of GHGs – may compete with China for first place**
  - **India very vulnerable to catastrophic disasters: like draughts in large parts of the country and flooding in others, fall in food production, spreading of disease, epidemics etc.**

Indian Energy Trends

- **Shortage of Power – likely to be more acute – use of DG**
- **Losses of Discoms – not able to supply available grid Power**
- **Rising Prices of Grid Power – IIM price + Rs 13.50 /kWh**
- **& high cost DG power**
- **Increasing coal imports – foreign Exchange outgo**
- **Lowering of RE prices – esp. SPV, Wind, Hydro & BE**
- **Fossil fuel Centralized Vs RE DC – T &D losses lower**
- **Finite fossil fuel Vs Infinite resources perpetually available**
- **RE is the solutions – Green Energy which is sustainable & without pollution & Global warming**

Indian RE Achievements

I. GRID-INTERACTIVE POWER CAPACITY (MW)

Sector	Target (FY- 2015-16)	Cumulative Achievement (as on 31.07.2015)
Wind Power	2400.00	23,864.91
Solar Power	1400.00	4101.68
Small Hydro Power	250.00	4130.55
Bio-Power (Gasification & Cogeneration)	400.00	4418.55
Waste to Power	10.00	127.08
Total	4460.00	36,642.77

Note: Total Indian Power installed capacity 284 GW

Solar Power in India

- Solar Photo Voltaic - 98%

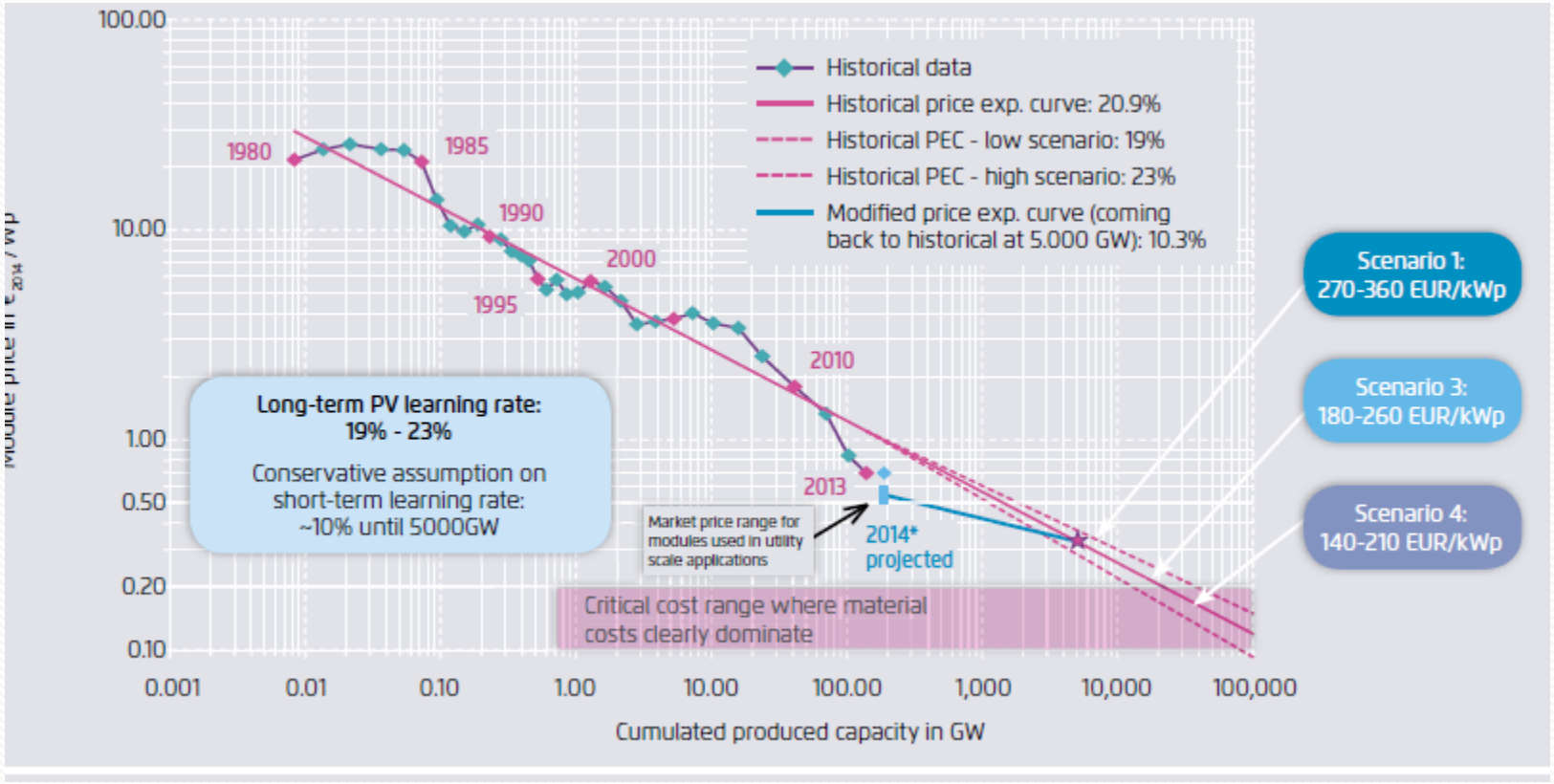
- Concentrated Solar (CSP) - 2%

- Solar Thermal Water Heating

Solar Power in India

- **Abundant resource – Estimated Potential 750 GWp (Rajasthan – 142,** J&K - 111, Maharashtra – 64, MP – 62**)**
- **We have touched the surface!**
- **World SPV Capacity 178 GW, India Ranking 10th - ~4GW, Germany 39 GW; USA – 20 GW**
- **Expected life of plant – 20 to 25 years**
- **No costs (fuel), very low O&M**
- **CSP – higher project cost, higher O&M, Water /thermic fluid required**
- **Limitations - Energy is limited to day time - Low PLF of 18% to 25%. Reliable Power Storage device needed**
- **Large area required – low efficiency**

Price Trend in Solar PV



SPV Power rates down drastically in last 5/7 years in India – from Rs 18 to Rs 5 to 6/unit

Solar Tariff trends in Germany

Solar power will soon be the cheapest form of electricity in many regions of the world.

Indian Railway – an Example of Solar Roof top Power

- Power consumption: 18 bill units/yr
- 5yr target of 1000 mW solar power
- Yr target 200 stn, 21 offices, 2000 LC
- Achieved 21 MW of solar and wind
- Katra Station:
  - C. Load 3.13 mW
  - S Plant Capacity 1 mW
  - Generation 1.45 mill unit/yr
  - Energy Saving ~ Rs 1 cr/yr
  - Carbon reduction 10,000 T/yr
  - Project cost 8.52 cr
  - CD 27/03/2015

Cochin Airport – An Example of Ground Mounted Solar Power

- Ground Mounted **12 mW** Solar PV Power Plant
- ~ **50 acres** near the cargo complex
- **Generate over 48000 units** of electricity daily
- Pr. Cost $9.5 million (~Rs 62 cr)
- **Kochi Airport Becomes World's First to Operate Completely on Solar Power**

Wind Power

- **Installable Potential at 80 m 102.8 GW**
  - **Gujarat – 35 GW**, AP -14.5, TN – 14.2, Karnataka -13.6
- **MNRE estimated wind Potential 191 GW**
- **Off shore Potential (7500 km coast line) - guesstimated at 500 GW , TN – 127 MW**
- **World Installed Capacity 370 GW, China 115 GW, India Ranking 5th - 23 GW**
- **Limitations – very high land use, low CUF – 20% to 30% , unreliable, offshore accessibility**

Wind Power - An Example

- **Capital cost Rs 6.0 cr & Large land area**
- **Project life of 25 & relatively low maintenance**
- **Net generation 1 MW = 1.93 MU to 2.80MU/yr**
- **RS India Wind Energy P Ltd, Satra Distt. , Maharashtra**
- **Actual capacity – 25 nos, x1.65MW= 41.25 MW**
- **Rotor dia – 82 M**
- **Net Power supplied to grid in 1 yr: 69,767MWh**
- **CO2 emissions reduced 62859 T (1.68 MU/MW)**

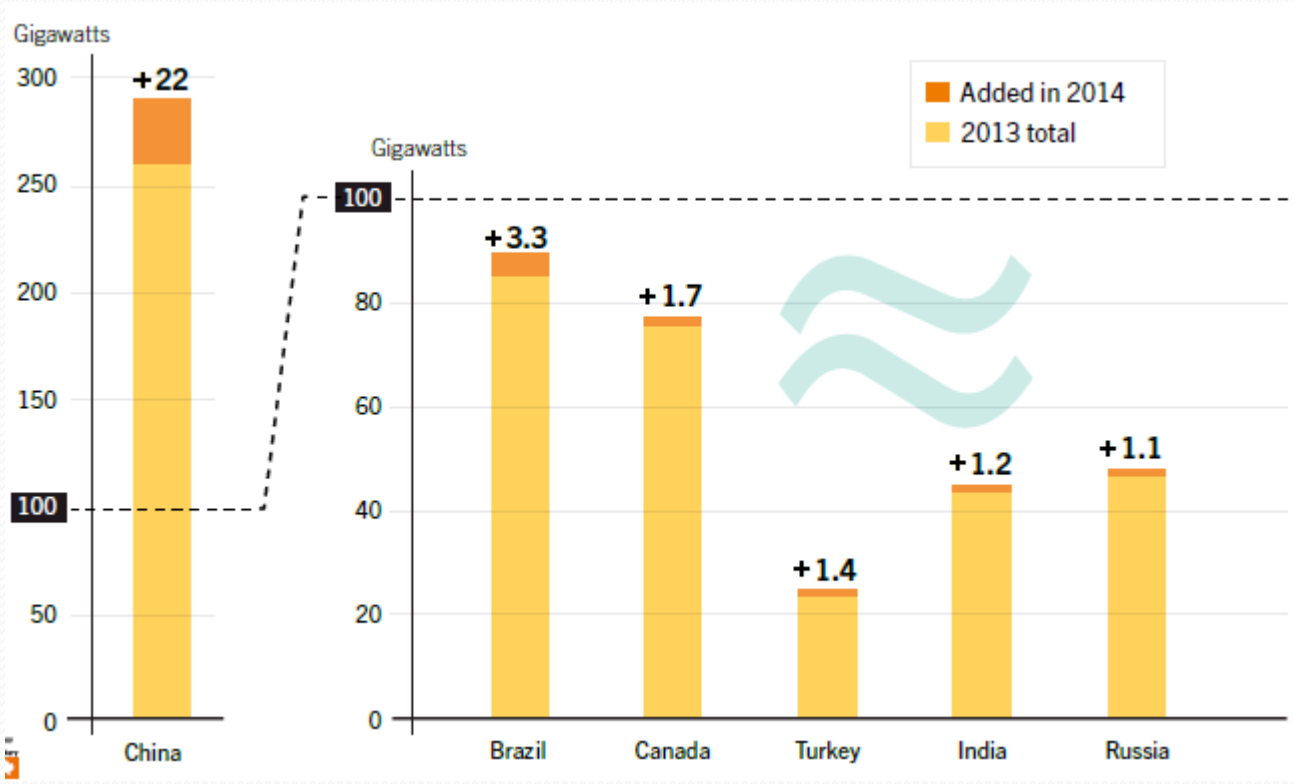
Hydro & Small Hydro Power

- **World Capacity - 1055 GW (37 GW added 2014)**
- **India Capacity Large Hydro ~42GW**
- **Small Hydro (below 25 mw) ~4 GW**
- **Potential LH ~150 GW;SH ~20 GW**
- **Hydro Project cost unreliable depending on geology & grid accessibility, Rehabilitation, Environmental issues**

Large & Small Hydro Power

- **Expected life of plant – 35 to 50 years**
- **No costs (fuel)**
- **Low O&M**
- **LHP PLF of 60% - Net Generation 1MW = 2.60 MU**
- **Low cost of Production –irrigation + Power**
- **Limitations:**
- **SHP PLF ~30 to 40%**
- **Depends on Monsoon,**
- **Large area required for Reservoir – Displacement issues**
- **Geological uncertainties**
- **Accessibility to Grid**

Top Hydro Power Countries



BioEnergy & BioPower

- **Abundant resource: –**
- **Major Agri-residues~800 Mill T:**
  - **170 mill T Rice straw;**
  - **120 mill T of Wheat straw;**
  - **120 mill T of Bagasse & leaves,**
  - **Many other Rice husk, Groundnut shell, Pulses; Cotton stock; coconut shell etc.**
- **Energy plantation**
- **MSW, Agriforest, Energy plantation, cooking waste, animal & human excreta**
- **Estimated Potential – 30GW**

BioEnergy & BioPower

- **BM Power instead of fossils for combustion**
- **BM/excreta for Biogas/BioCNG**
- **Starch, Sugar, biomass for Ethanol**
- **VO for Biodiesel, BM Pyrolysis Oil, hydro processing REdiesel/Petrol/Jet**
- **Most Farmer/Rural development friendly**
- **Limitations: BM/ Agri-residue costs vary, & escalate, effect of drought**

Maharashtra Tariff for FY2014-15

S.No.	Power Sector	Rate of Power (Rs /kWh)
1	Hydro (25/5 to 5/1 MW)	4.33 to 5.06
2	Wind (CUF 30% to 20%)	3.92 to 5.70
3	Biomass (Cogen – Biomass)	6.27 to 6.43
4	Solar PV (GM - RT)	7.95 to 8.45

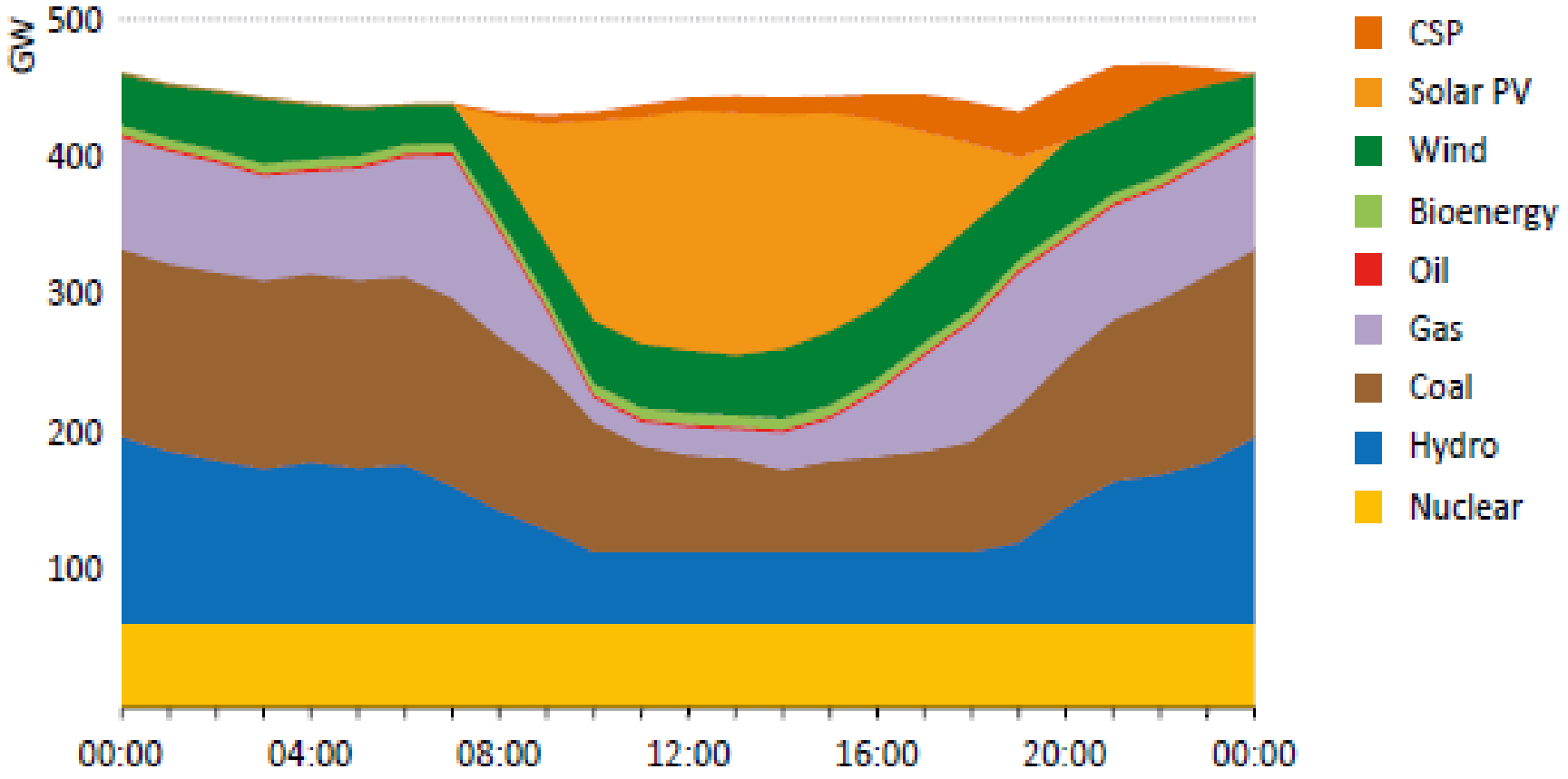
Exciting Future

- Germany cost of PV power 7.8 cent /kWh (Rs 5.5/kWh)
- Middle East <Rs4/ kWh
- CCS option but not commercially proven & special geological structures needed - may not be available
- Subsidy on Fossil fuels $500 bill but carbon tax needs to be added
- Additional Health and environmental cost of Coal Power in USA $500 bill.
- Investments in RE to grow to $400 billion/yr in 2030
- Economy will grow by 88% by 2030 but energy-related CO2 emissions to increase by 8%

Indicators of Mainstreaming

- **The Guardian:**
  - **Friday July 10, 2015, Denmark - Wind power generates 140% of electricity demand**
  - **"It shows that a world powered 100% by renewable energy is no fantasy," said Oliver Joy, a spokesman for trade body the European Wind Energy Association.**
  - **Denmark nearly 39% of total power consumption of was met by RE in 2014 Target of 50% by 2020 & 100% by 2050**
- **Saturday, July 25, 2015, Germany - 78% Power from RE beating record - 74% set in May 2014, Power from RE more than 8 times in 25 years, Avg. of nearly 30%**
- **Greenpeace - most accurate in predicting in last decade – Projects 100% RE by 2050**
- **India Target for 2022: GMSP 60; RTSP 40; W 60; BM10; Hydro 5 = 175 GW**

Indian Illustrative Load Curve 2040



It is certain that non carbon, clean energy will be the dominating energy

with

RE being the MAINSTREAM in the second half of 21st century

Thank You !

BIOMASS Options