Energy & Water linkages in the power sector – Implications for future planning

Presentation at

Conference on Water Optimization in Thermal power plants

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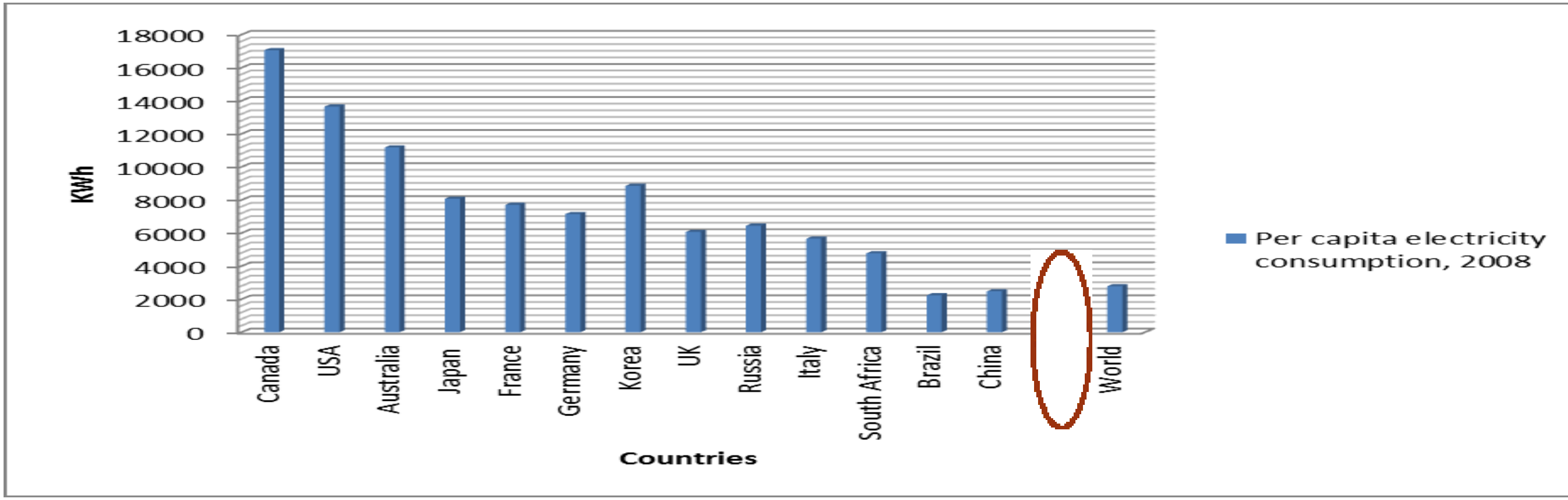
Outline

- **Power Sector in India**
  - Demand for power
    - Current (total & per capita); comparison with other countries
    - Future : Business-as-Usual (BAU) Scenario
- **Water use in Power Sector**
- **Implications for water requirements**
  - BAU Vs. Alternative pathways
- **Variation in water use in conventional power plants** [Discussion on norms & water saving measures]
- **Water & Energy linkages**
  - Are there trade-offs?
  - What can we say for specific sites that may be water stressed or coastal/inland plants
  - Implications of increased water stress due to other sectors
- **Case Study—Thermal power plants water audits**

- India’s per capita electricity consumption is a fraction of that of other countries



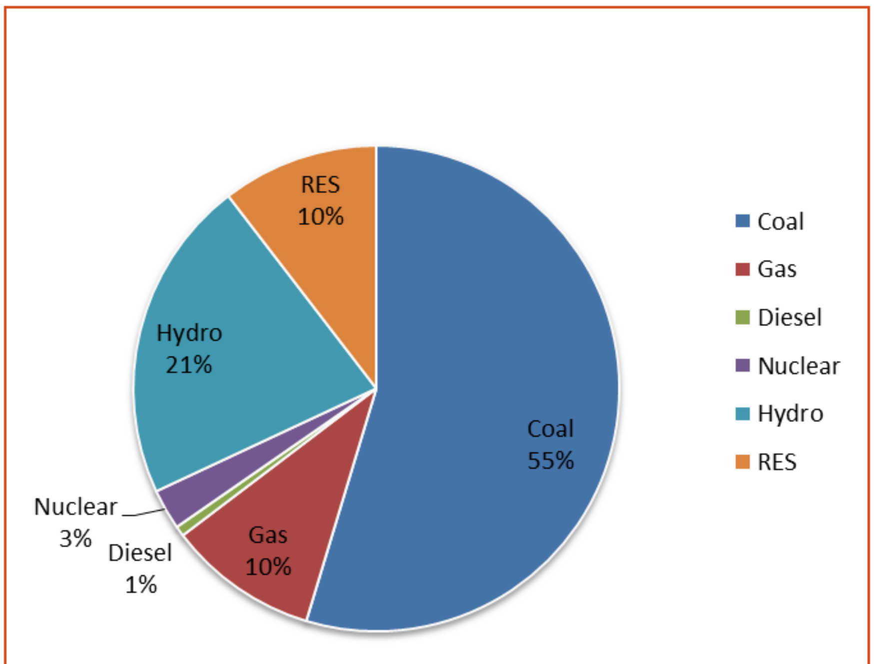
Source: IEA

- Electricity consumption expected to increase 5-6 times 2001 level by 2031 (TERI, 2009)
- Peak deficit of 9% in 2012-13; energy shortage 8.7 % in 2012-13 (CEA)
- Power sector an important contributor to growth, but high use of energy, resources & implications on emissions.
    - Energy consumption for power generation: ~ 42 % of total commercial energy (TEDDY 2012/13)
    - Accounts for ~ 53% of energy sector emissions in 2000 (MoEF, 2012)
    - Thermal power plants are highest water users amongst the industrial sector (1-2 %);
    - Limited areas of land amenable for siting new plants

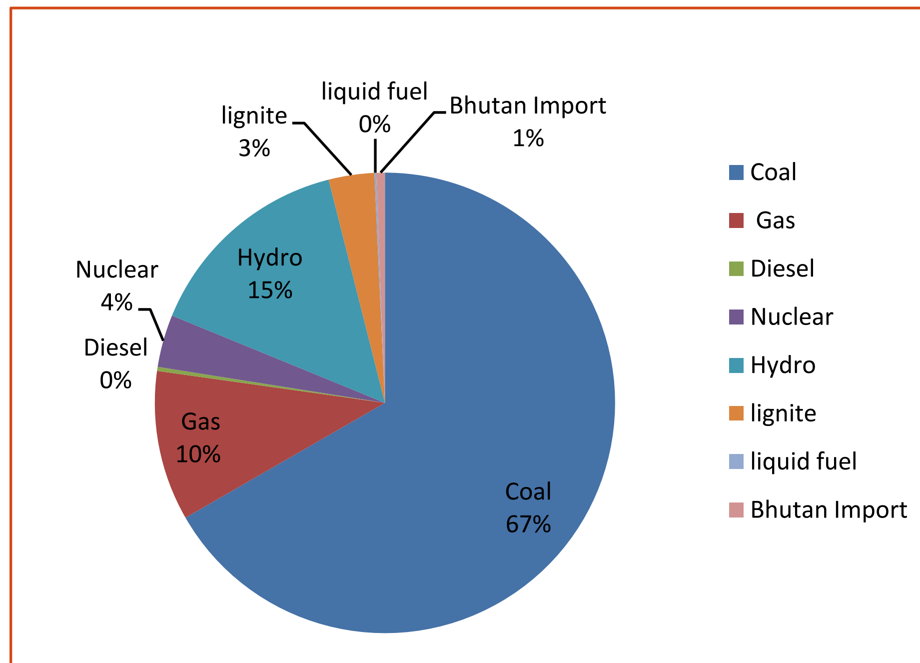
Power Scenario in India

- Need for rapid growth in power generation – HDI & development strongly linked
- Highest power consumption in Industrial sector (35.34 %) followed by Domestic (25.07%), Irrigation (21.02%) and Commercial (10.16%) and others (8.41%) in 2009-10
- On the supply side, coal continues to be the mainstay, followed by hydro & gas; although capacities of nuclear, renewables increasing
- Future transitions relevant from various perspectives (meeting energy & peak demands, adequacy of fuel supplies, land & water availability; environmental implications)

All India Installed capacity as on 30th June, 2011



Fuel wise energy generation in 2011-12

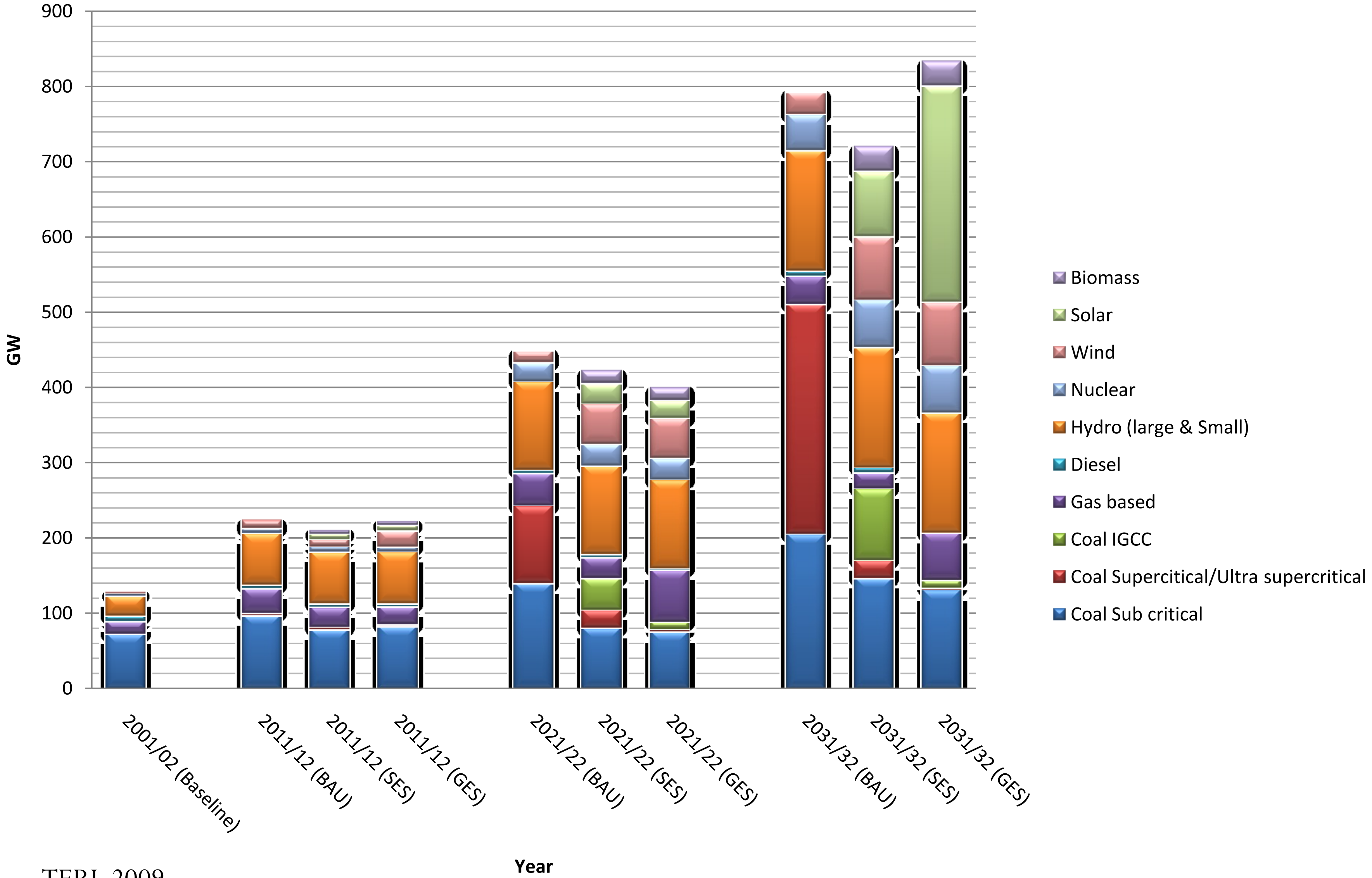


Possible Future Energy Scenarios

Scenario Name	Storyline
Reference Energy Scenario (BAU)	Life continues pretty much as we know it, with autonomous efficiency improvements taking place where feasible, increase in use of renewable energy carrying on at the same pace and defined policy priorities being implemented with no real sense of urgency
Sustainable Energy Scenario (SES)	A determined effort is provided here for efficiency improvements both on the supply and demand sides, an accelerated push for renewable energy, nuclear and new technologies like CTL(coal to liquids) and GTL (Gas to Liquids). Energy Security concerns are paramount in this scenario
Global Equity Scenario(GES)	This scenario honours the Prime Minister on 'common but differentiated responsibilities' and equitable per capita rights and take on even more stringent emission reduction targets (reaching 1.24 tonnes /capita in 2031) towards influencing global response to the challenge of climate change.

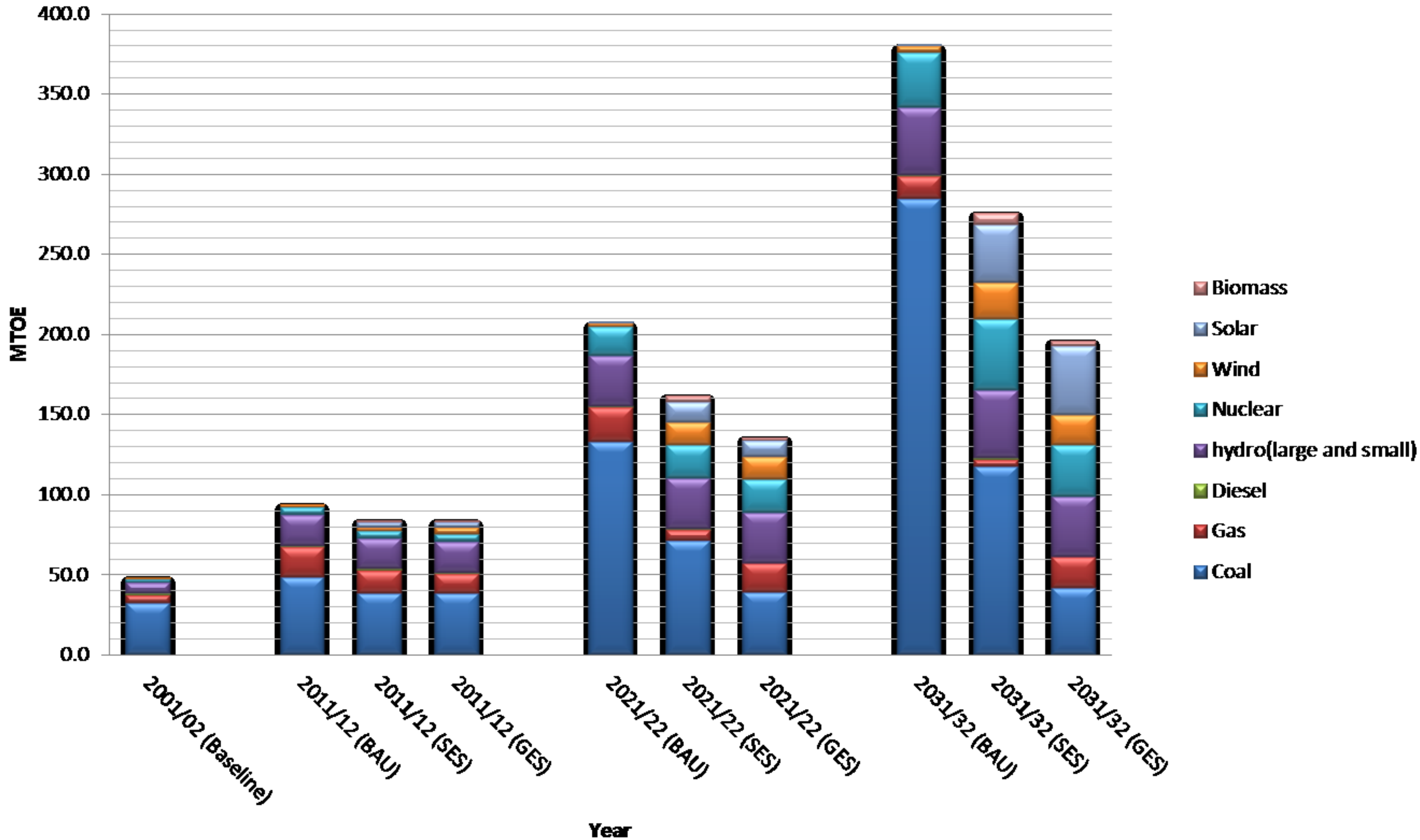
TERI, 2009

Power generation capacity across scenarios



TERI, 2009

Energy implications for power sector across scenarios



TERI, 2009

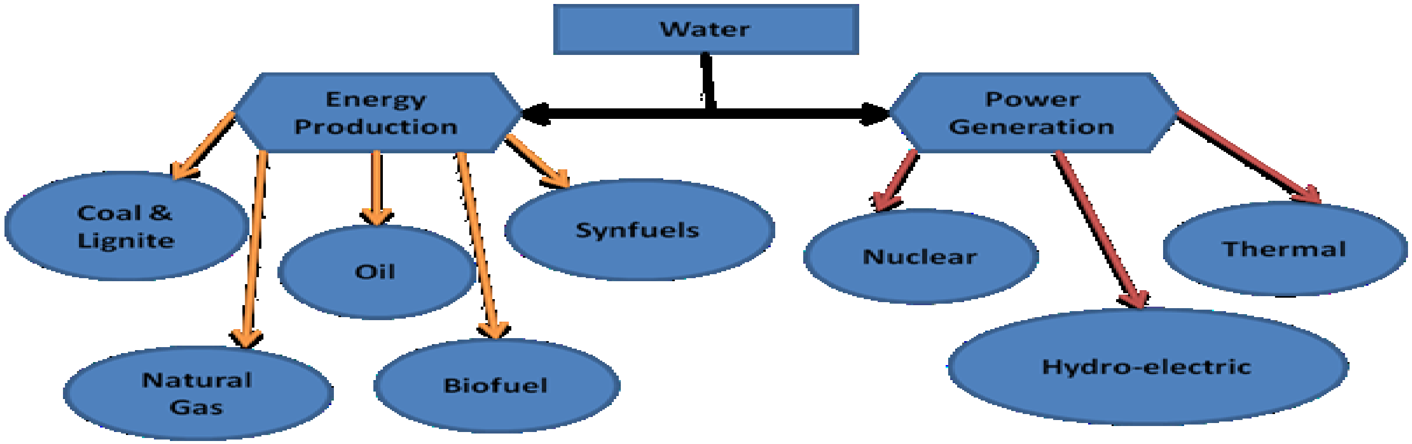
What does this imply in terms of the pressure on energy requirements?

- Import implications
  - Huge imports in the BAU scenario; e.g. around 450 and1282 MT of non-coking coal in 2021/22 and 2031/32 respectively
- Infrastructure implications
  - At ports and rail /road network for movement of fuels
- Emission implications
  - CO_2 & local air/water pollution

→ BAU not feasible in terms of energy – need to diversify to other fuels

Water use in the power sector (macro assessment)

- Water— A key resource to extract, produce, process or to convert energy from one form to another.



- Hydroelectric power plants, as such, do not have any consumptive use of water.
- Most renewables like wind, solar and biomass are not associated with high water requirement
  - Within solar, solar thermal has a higher water requirement than solar PV technology
- Water in power generation from fossil fuels like coal, gas, diesel, naphtha & nuclear is mainly for generating steam and cooling purposes.
- Nuclear power plants use more water for cooling purpose as they dissipate all the heat through water as in contrast to coal, gas etc. that partly dissipate heat through flue gas
- Coal and Lignite also use a significant amount of water for ash disposal, apart from steam generation & cooling purposes.
- Water stress more a site specific concern
  - Dependent on level of capacity by fuel & technology
  - Function of other competing demands

Water-for-energy— Current estimates and projections by various agencies

Water Requirement for Various Sectors

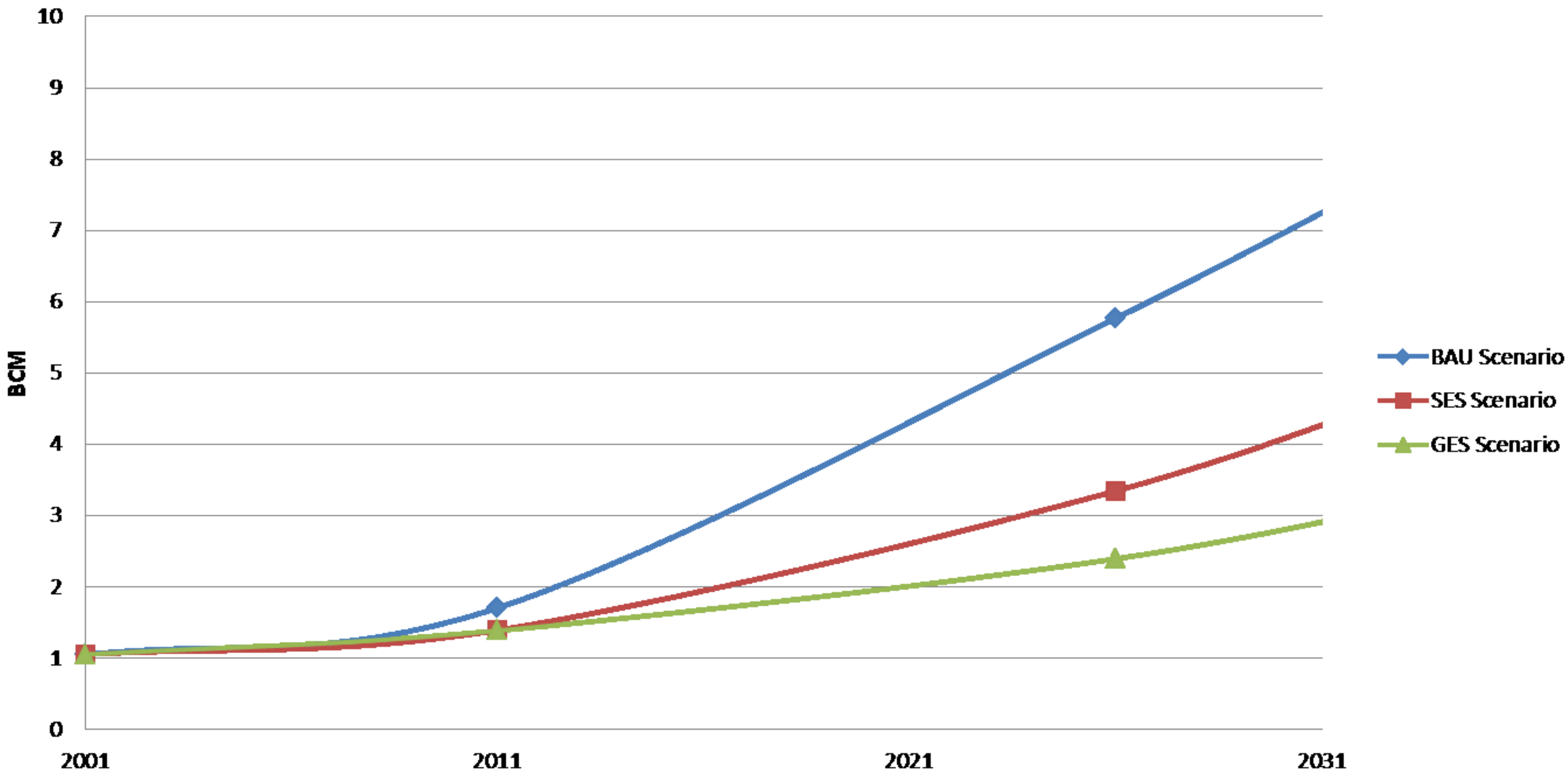
Sector	Water Demand in km^3 (or BCM)					
	Standing Sub-Committee of MoWR			NCIWRD		
Year	2010	2025	2050	2010	2025	2050
Irrigation	688	910	1072	557	611	807
Drinking Water	56	73	102	43	62	111
Industry	12	23	63	37	67	81
Energy	5	15	130	19	33	70
Others	52	72	80	54	70	111
Total	**813**	**1093**	**1447**	**710**	**843**	**1180**

- Wide variations in water requirement for energy; however water requirement estimated to increase significantly as per both norms
  - NCIWRD, 1999; MoWR Sub Standing Committee, 2000

Variation in water use in conventional power plants

- Water intensity in power generation is a function of fuel type, technology used and water conservational practices followed during energy generation
- Variations in water use can be because of following:
  - **Fuel type**—Nuclear > Coal/lignite > Gas/Diesel > Renewables
  - **Technology**—Subcritical, Supercritical, Ultra-supercritical, IGCC, CSS, etc.
  - **Processes**—Wet cooling vs. Dry cooling, Closed loop vs. open loop cooling, Lean slurry disposal system vs. High concentration slurry disposal (HCSD) system etc.
  - **Water conservational measures**—Utilization of cooling tower blow down for ash disposal, dry fly ash disposal, bottom ash water recycling, etc.

Implications for water requirements* BAU vs. alternative pathways



Inference: A shift towards renewables in the SES & GES scenarios could result in much lower water consumption as compared to that in the BAU scenario

Comparison between CEA & NCIWRD norms

- CEA—3000 m^3/hr. for a typical 2 X 500 MW coal based inland plant or **3 m^3/MW/hr** with closed loop cooling, dry fly ash disposal, bottom ash water recycling and cooling tower blow down used for ash disposal and a few more water conservational practices (CEA 2012)

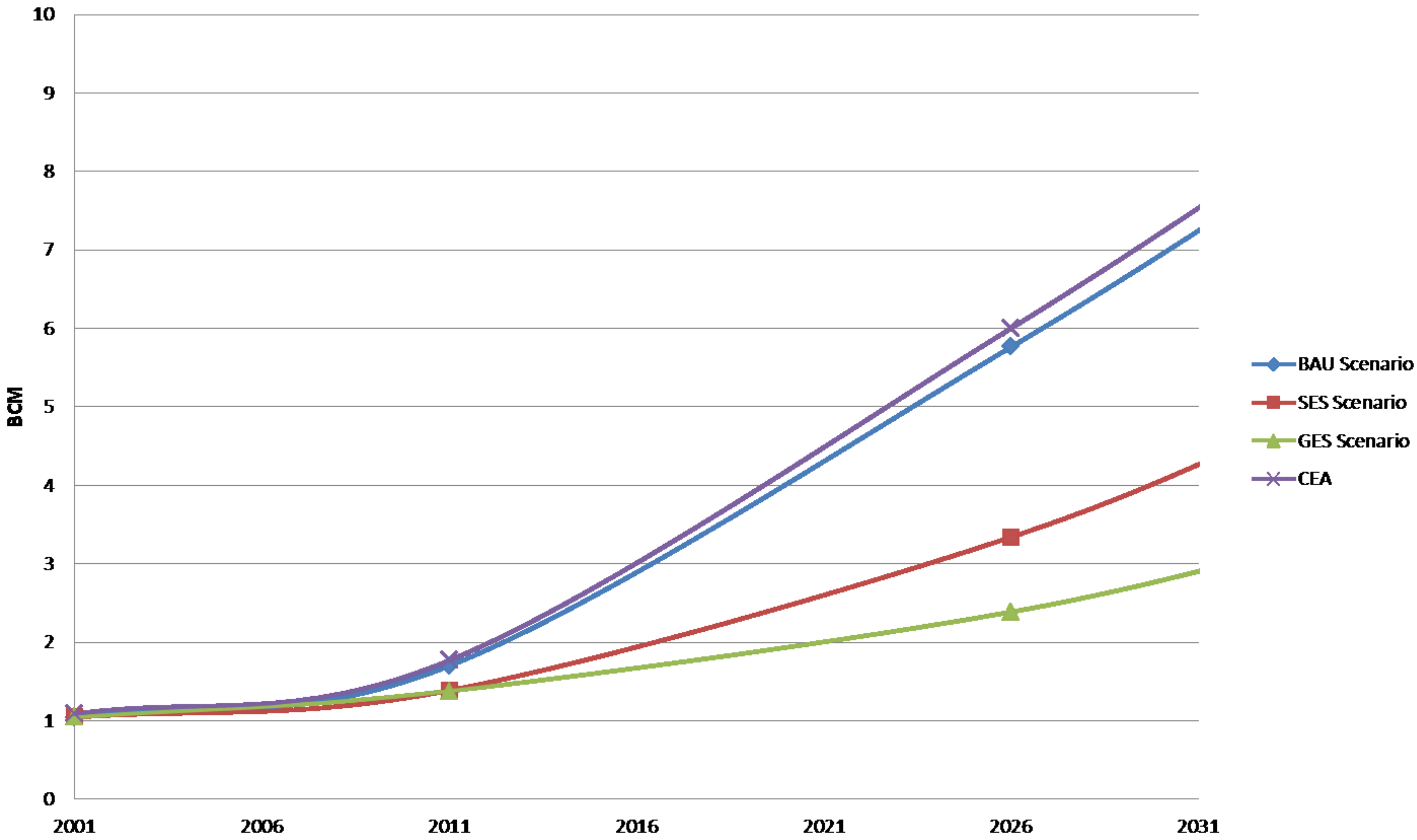
Sl. No.	In-land plants using indigenous coal	In-land plants using indigenous coal		Sea water based coastal plants(fresh water requirement)
		Plants with wet cooling tower	Plant with dry cooling system	
1.	Water requirement for first year of plant operation	3600	750	400
2.	Water requirement during subsequent period	3000	550	

- NCIWRD, 1999

Category	Unit	2010		2025		2050	
		Low	High	Low	High	Low	High
Thermal	0.001 BCM/100MW/year	2.38	2.63	2	2.21	1.43	1.58
	m3/MW/hr.	2.72	3	2.28	2.52	1.63	1.8
Nuclear	0.001 BCM/100MW/year	2.85	3.15	2.85	3.15	2.85	3.15
	m3/MW/hr.	3.25	3.6	3.25	3.6	3.25	3.6
Solar/wind	0.001 BCM/100MW/year	0.17	0.18	0.17	0.18	0.17	0.18
	m3/MW/hr.	0.19	0.21	0.19	0.21	0.19	0.21
Gas Based	0.001 BCM/100MW/year	0.45	0.49	0.45	0.49	0.45	0.49
	m3/MW/hr.	0.51	0.56	0.51	0.56	0.51	0.56
Hydro	BCM	LS*	LS	LS	LS	LS	LS

*LS Live Storage

Comparison of results obtained from Norms

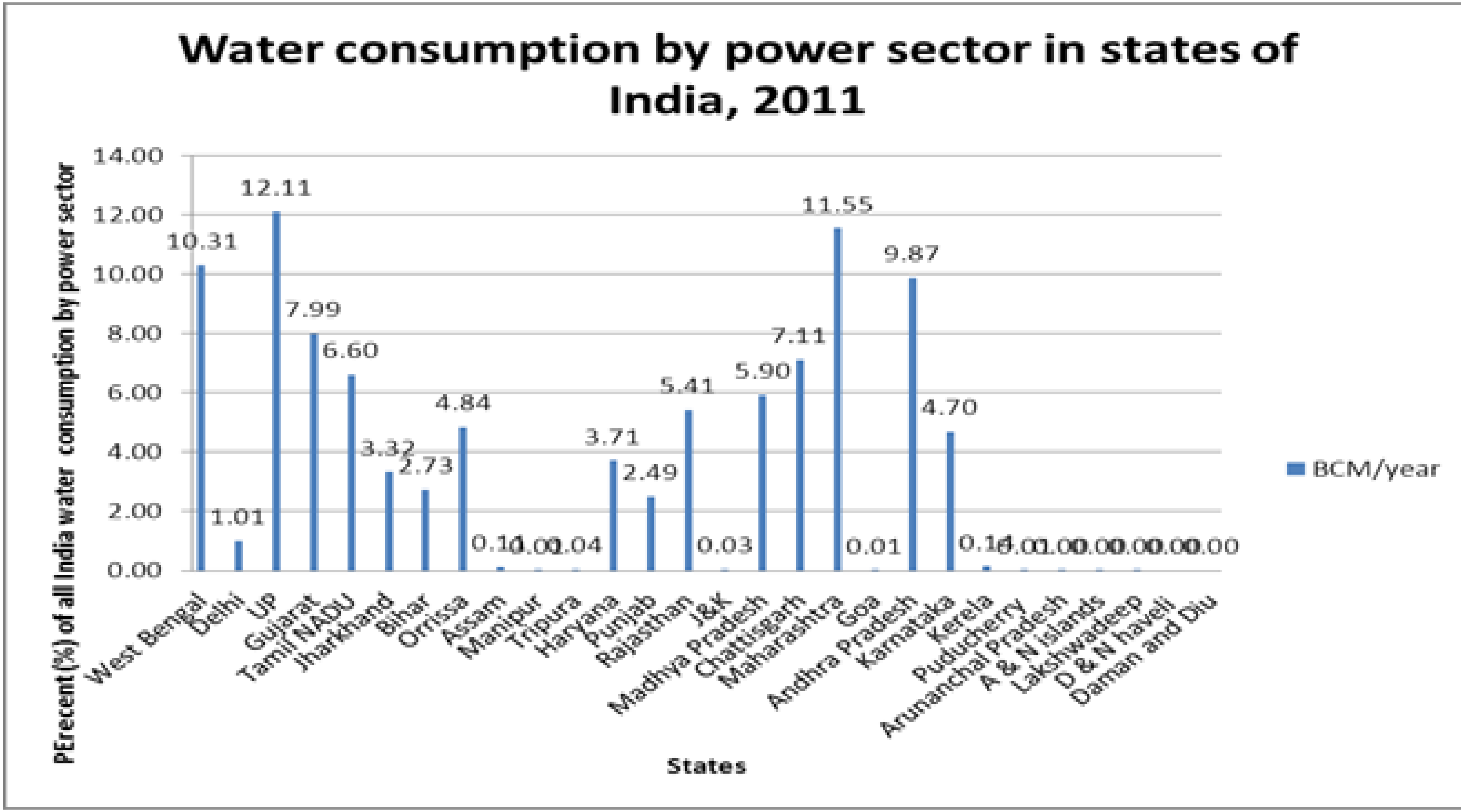


CEA norms imply slightly higher water consumption as compared to NCIWRD norms, although they consider several water saving measures

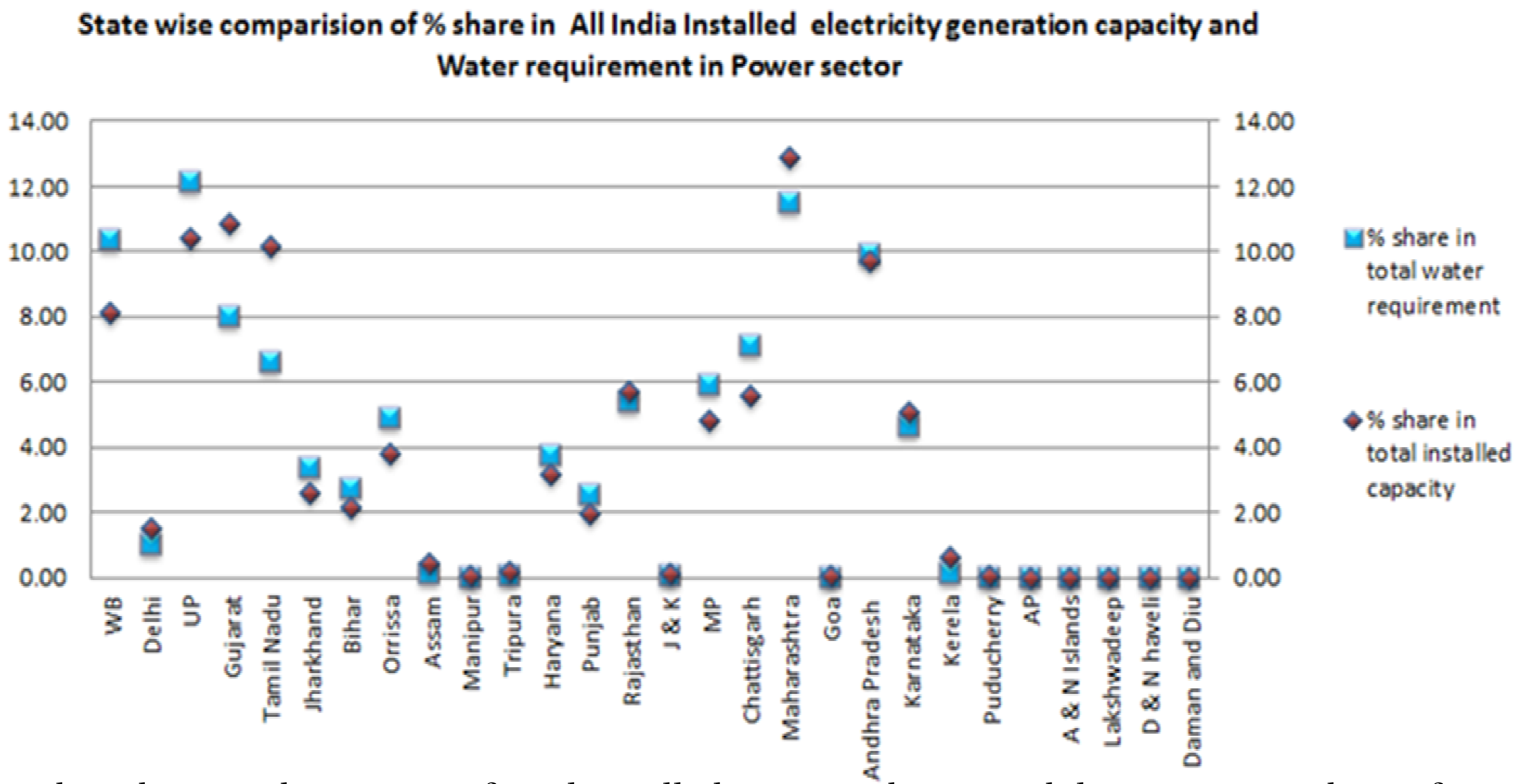
Comparison of overall water consumption based on norms

- The norms specified by CEA for coal based thermal power plants seems to be an underestimate of water consumption. The norm of water requirement of $3m^3$/MW/hr. is based on inclusion of several water saving measures
- The norms suggested by NCIWRD for 2010 are even lower than those of the CEA [higher estimates are closer to CEA norms]
  - Water requirements of power plants as indicated in our scenarios therefore likely to be underestimates
- However, all the power plants currently may not be following all these practices; important to consider technical / economic feasibility of applying measures / practical considerations
- Understanding the water-use parameters (specific water consumption) and water-saving technologies/processes/ practices followed by the power plants can help arrive at a better understanding of the likely water stress at various locations.

State-level analysis of water used in power sector using NCIWRD norms



UP, Maharashtra, West Bengal are the top three water consuming states in the power sector including all renewable and non-renewable energy source



- Maharashtra (with 12.91 % of total installed capacity) has a much lower percent share of water consumption as compared to percent share in installed capacity due to high penetration of renewables in the state.
- States like Uttar Pradesh and West Bengal draw significantly more water than their share in total installed capacity of India due to very high share of coal/ nuclear based power generation and insignificant renewable based power generation in these states.

Water and Energy Trade-offs

Cooling Type	Water Withdrawal	Water Consumption	Capital Cost	Plant Efficiency	Ecological Impact
Once-Through	intense	moderate	low	good	intense
Wet Cooling Towers	moderate	intense	moderate	good	moderate
Dry Cooling	none	none	high	bad	low

Summary of Cooling Systems Trade-offs (Delgado, 2012)

- Closed loop has lower water withdrawal , but higher water and energy consumption
- Lean slurry versus high concentration slurry disposal: HCSD system has lower water requirement but high energy consumption
- Some increase in auxiliary energy consumption may be associated with water conservation measures.
- What factors need to be evaluated in considering trade-offs?
- Several options may exist to simultaneously look at energy and water saving at existing power plants
- What incentive do power plants have to follow water conservation practices?
- Siting of new plants should also examine future water stress along with other factors

Maharashtra: Parli power plant shuts down after severe water crisis

Reported by Rashmi Rajput, Edited by Amit Chaturvedi | Updated: February 17, 2013 17:33 IST

Mumbai: All six units of the Parli thermal power plant in Beed district of Maharashtra have been shut down because of severe water shortage in the Marathwada region. The plant used to receive water from the Khadka dam but the supply was stopped as the water level in the dam has almost dried up.

"Due to water shortage we had to shut down the plant. 1160 MW energy was generated by the plant. Two units were shut in October last year and all the six units were shut yesterday," said MM Chavan , chief engineer of the plant. The power plant has an installed capacity of 1130 MW.

Power or water for Vidarbha?

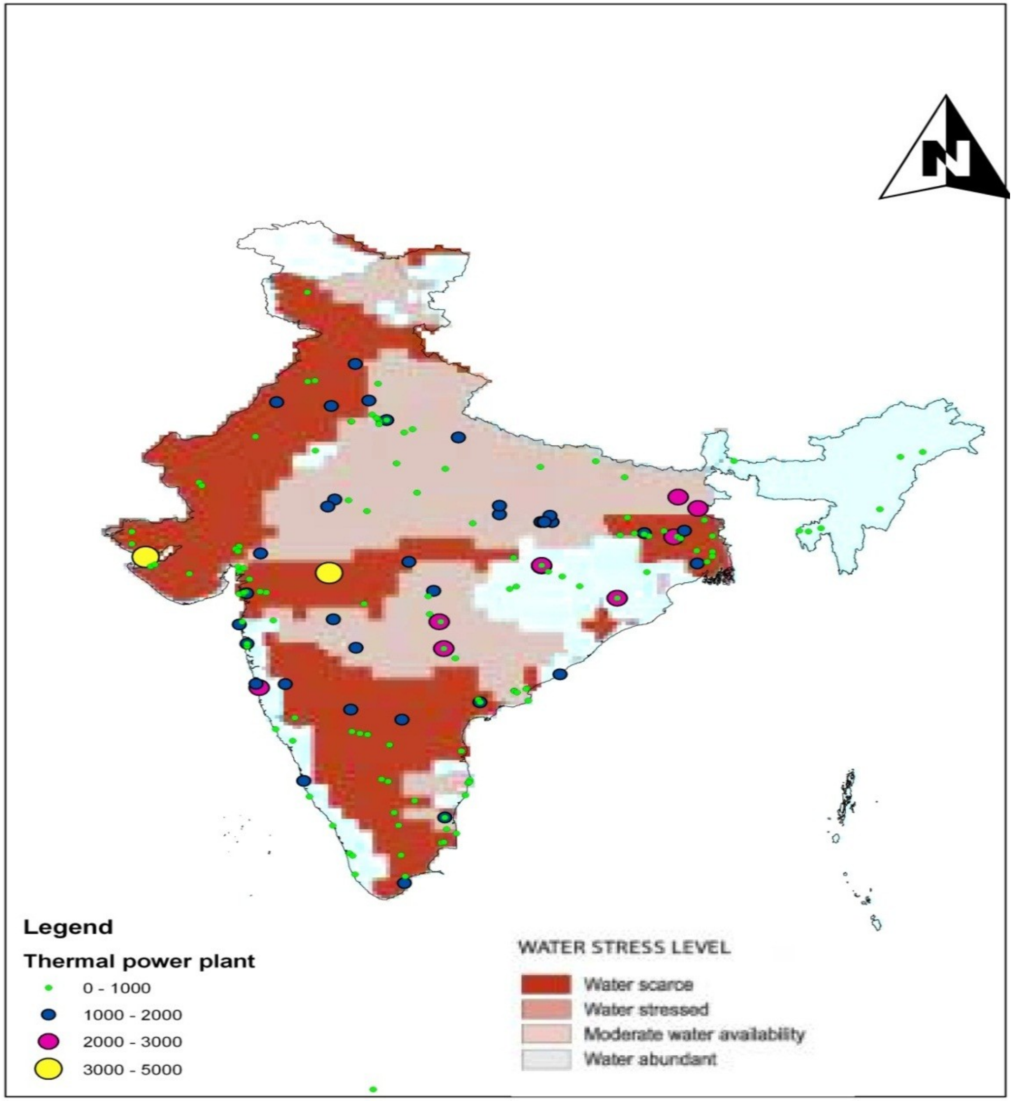
Jayashree Nandi, TNN Aug 7, 2012, 04.23PM IST

Tags: Vidarbha Statutory Development Board | vidarbha | thermal power plants | Greenpeace

NEW DELHI: Water starved and already plagued by a massive agrarian crisis, Vidarbha may now have to deal with more woes. Large clusters of thermal power plants proposed in Vidarbha will dramatically intensify the water crises in the region and eat in to the irrigation sources.

An IIT Delhi study commissioned by Greenpeace India released on Tuesday revealed that the proposed power plants may bring down the future availability of water in the Wardha river in Vidarbha by 40% and affect irrigation for about one lakh hectares of farmland in the future.

Though the magnitude of water consumption/withdrawals by power sector may not be that high in magnitude but local water stress that they create also due to demand from other competitive users can be quite significant



Water Audit

(Reducing water consumption & improving efficiency)

Case Study

Thermal Power Plant

Approach & Methodology

Secondary data collection → **Reconnaissance survey**

Flow monitoring and establishment of water balance

- Entire **water** supply **network** of **Stage-I, II & III**
- **Drinking water** supply and **sewage** water discharge from **township**.
- **Leak detection** & estimation of UFW
- Estimation of **cycle of concentration (COC**) and **water consumption/MWH**

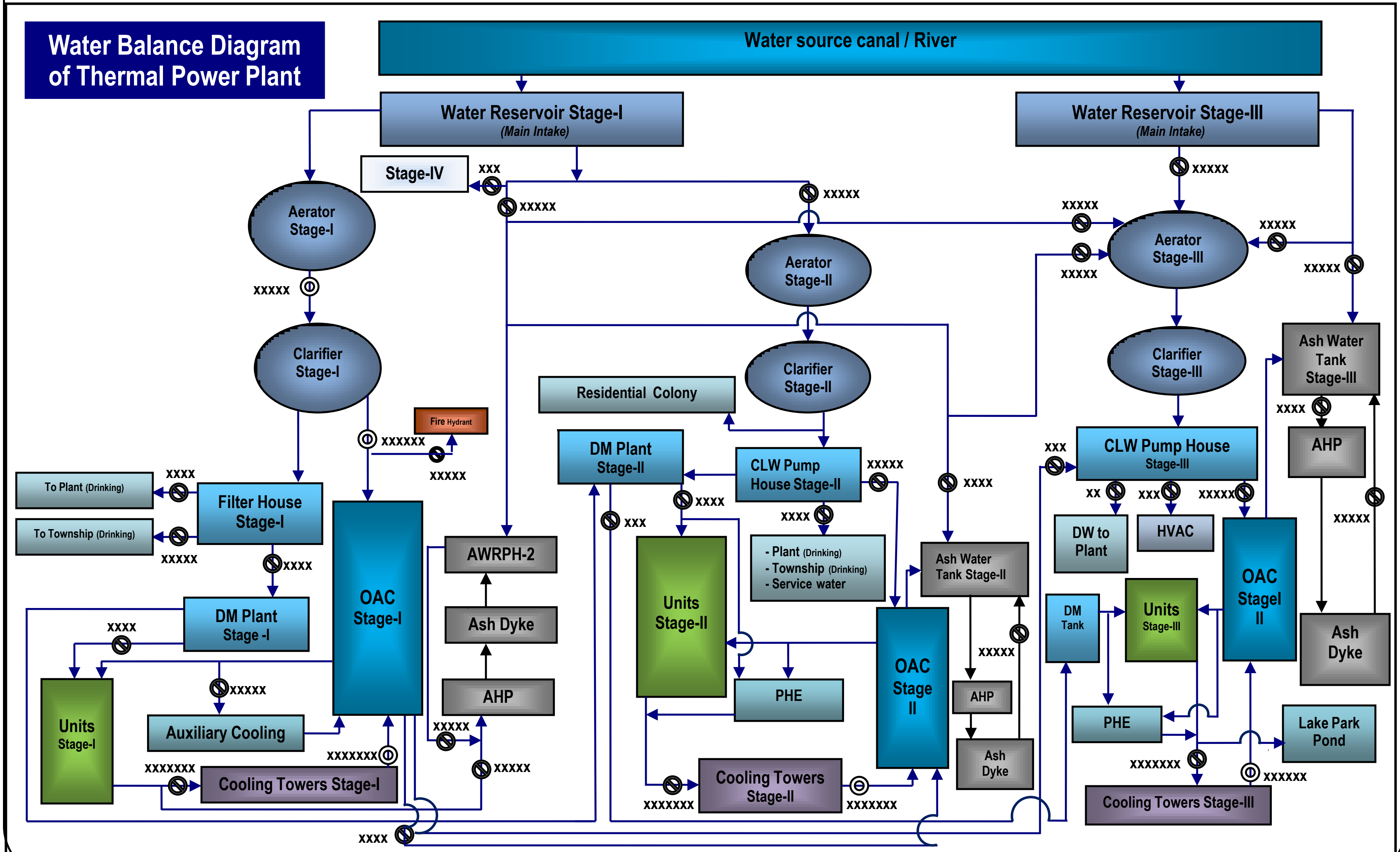
Water Quality Monitoring & Characterization

- Water **sampling** (at various locations at **Stage-I, II & III** eg. for Intake Water, Process Water, OAC, Drinking Water, and Wastewater discharge)
- **Laboratory testing** & analysis

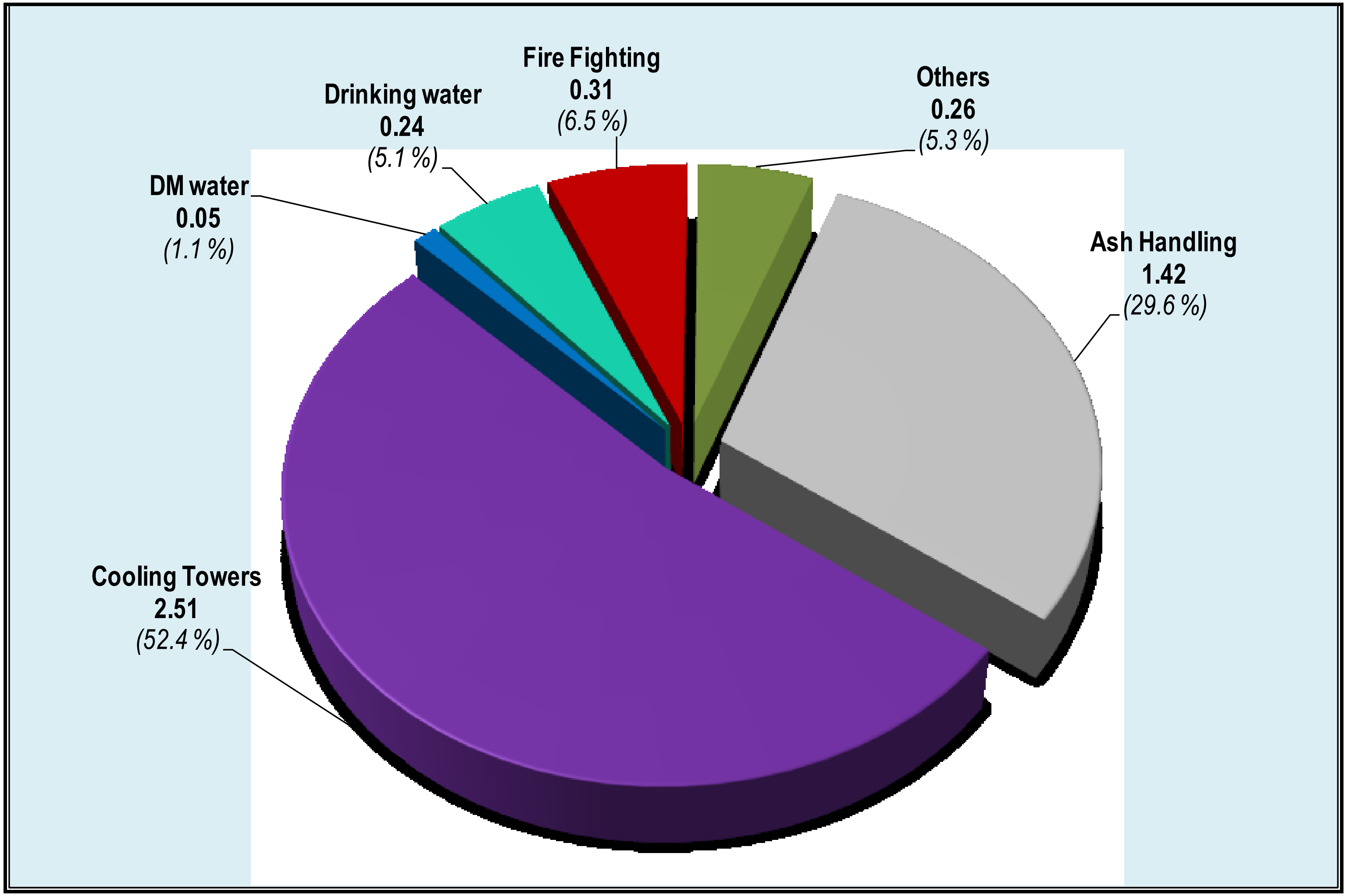
Data analysis & Recommendations for water & wastewater management

Establishment of Water Balance:

(Water flow & quality profiling)



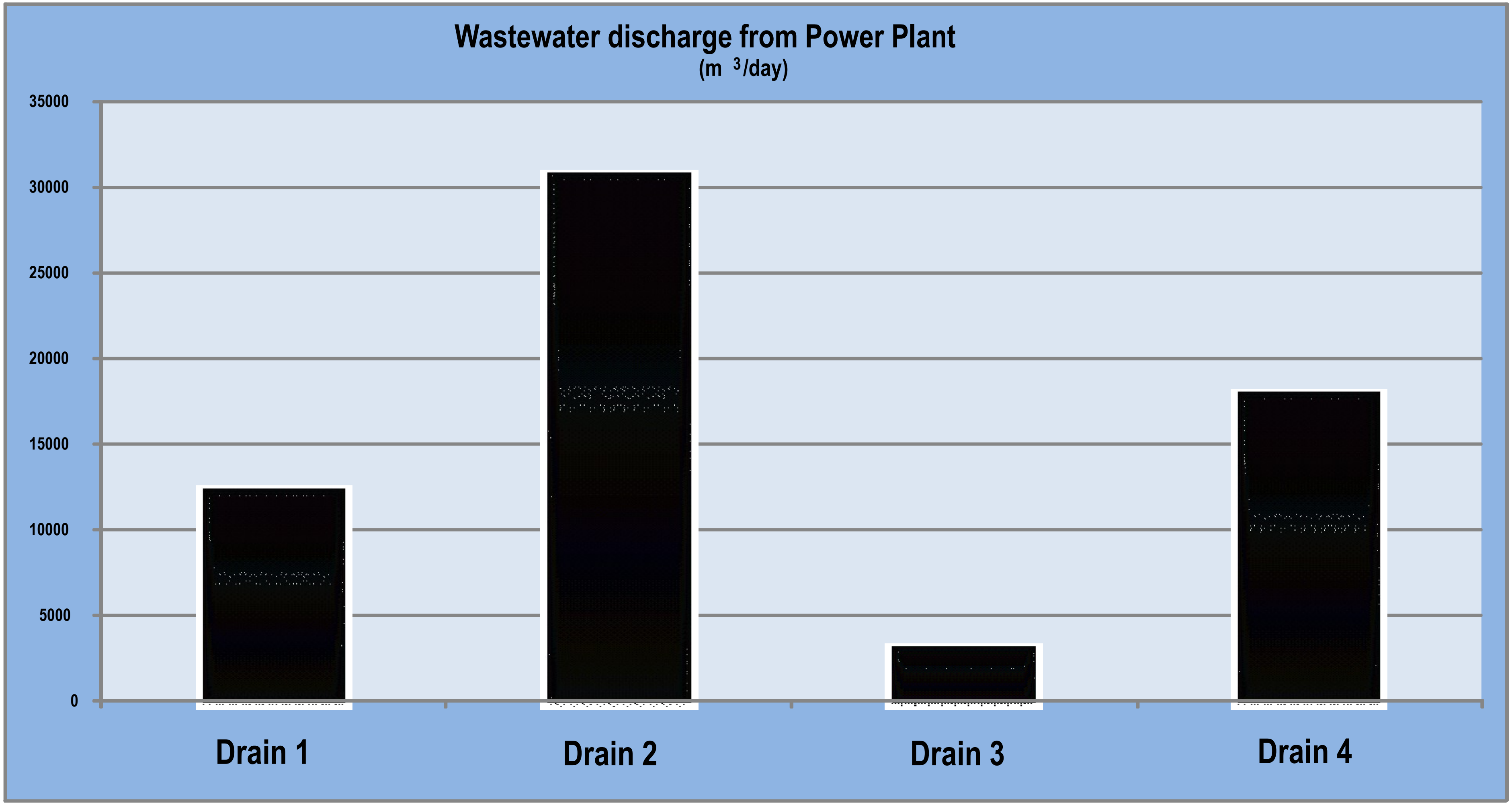
Specific Water Consumption (m^3/MW)



Actual Overall Specific Water Consumption – about 5 m^3/MW

Scope for optimizing (Achievable SWC) – 3 m^3/MW

Wastewater Discharge



- **Total Wastewater Discharged** ***(unused)*** = 64000 m^3/day **(About 18% of Intake water)**
- **Wastewater quality** reasonably **good for recycling (Zero Discharge)**

Recommendations for water conservation

- **Water** for **boiler auxiliary** (discharged as waste) should **be reused** .
- High **water loss (80-50%)** in **ash handling** should **be brought down** (overflows should be recycled, leakages plugged, Specific water consumption brought down)
- **Cooling Towers**: **COC** must be **increased**, **Specific water consumption** should **be reduced** (to about 1.5 m^3/MW), **overflows** must be **checked**.
- **Township**: **Reduction** in **per capita water consumption** (to 150 lpcd)
- **Recycling** of about 64000 m^3/day of **wastewater** being discharged from the plant to **achieve Zero discharge** through a **treatment plant**.
- **Township STP discharge water** (suitable for horticultural uses) should be **reused** entirely thus **saving** significant water and **ensuring zero discharge**

Potential for water saving

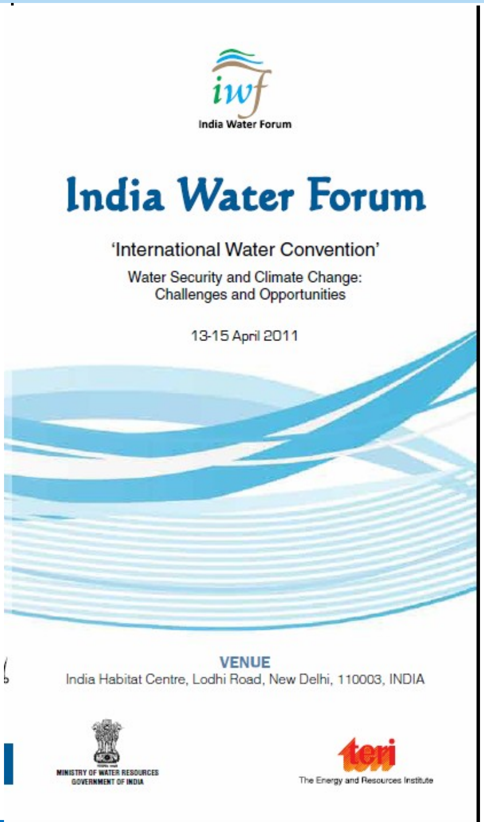
- Immediate saving potential of **about** (81000 m^3/day) **23%** of total **intake water**

- **Significant financial savings** from water saving interventions of about **INR 7-9 Crores**.

- **Cost benefit** of water recycling system was positive with a **payback period** of just **2.3 years**.

India Water Forum

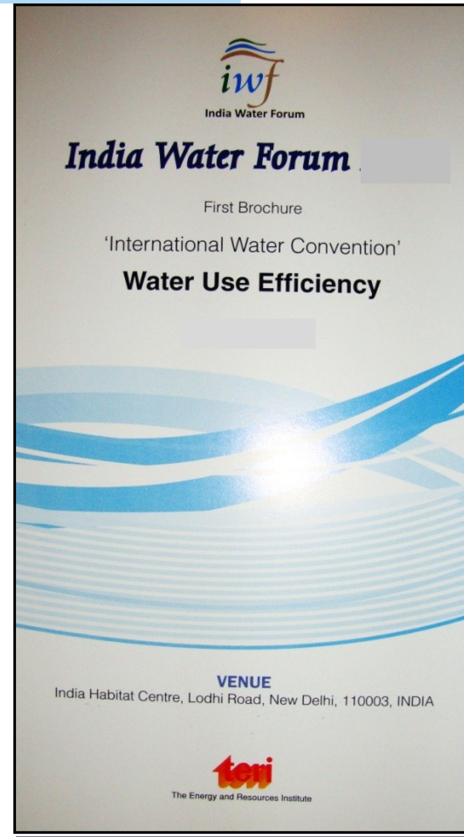
India Water Forum



2011 : Water Security and Climate Change: Challenges and Opportunities

International Water Conventions

2013 (October) : Water use efficiency



2013: Water use efficiency

Thank You !