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POLICY BRIEF

Benchmarking Industrial Water Use Efficiency in India

Opportunities for Water-Intensive Industries

National Water Mission

Ministry of Jal Shakti

THE ENERGY AND RESOURCES INSTITUTE

Creating Innovative Solutions for a Sustainable Future

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Abstract

The rapid expansion of population and industrial activities in India has led to acknowledging the critical importance of water conservation. Addressing the escalating water usage within water-intensive industries is essential, given their significant contribution to the economy alongside their substantial impact on water resources. Amongst the water-intensive industries, thermal power plants are the highest consumer of water, followed by pulp & paper, textiles, and iron & steel industries. Existing challenges or inefficiencies in water management practices, such as over-extraction, pollution, or lack of wastewater treatment, further exacerbate the situation. Implementing benchmarking strategies can be beneficial in assessing and enhancing water use efficiency within these industries.

The Energy and Resources Institute (TERI), India, with support from the National Water Mission (NWM), Ministry of Jal Shakti, Government of India, conducted a comprehensive evaluation of water-intensive sectors in India, viz. thermal power plants, textile industries, pulp and paper industries, and iron & steel industries. The objective was to support industries in enhancing their water usage efficiency and to aid policymakers in promoting the overarching goal of improving water use efficiency and conservation. The assessment identified opportunities, technologies, best practices, and policy interventions for reducing the specific water consumption and enhancing water use efficiency within these sectors based on field water audits and secondary data assessments. Some of the specific highlights in the assessment include increasing Cycles of Concentration (CoC) in cooling towers, adopting dry ash handling and high-concentration ash slurry systems in thermal power plants; optimizing nozzle size in paper machines, and transitioning to advanced technologies such as flash condensing and dry pulping in Pulp & paper industries. Similarly, embracing computer-integrated machines and employing counter-current washing methods in textile industries can diminish water consumption. In the iron and steel industries, a notable reduction in water usage can be achieved by transitioning to coke dry quenching. These interventions along with opportunities for wastewater recycling/reuse etc. formed the basis for identification of potential benchmarks for water use in these sectors besides policy interventions to promote them. The opportunities unveiled in this assessment hold considerable potential for significant water savings within each industrial sector, offering valuable insights for the development of policies aimed at improving water use efficiency.




1. Introduction

With the ever-increasing population, rapid industrialization, and developmental activities continuing at a relentless pace, the pressure and impact on water resources have become increasingly challenging. India remains water stressed and is inching closer towards water scarce category[1] (CWC, 2019), while its increasing overall water demand is expected to reach 1,500 bcm (by 2030) (2030 Water Resources Group, 2009). In consonance with the pace of industrial development, and with about 8% of the total water withdrawal, the industrial water demand in India has been on the rise and is expected to increase many folds from 56 BCM in 2010 to 151 BCM by 2050 (CWC, 2014). The growth in some of the water intensive industries like coal based Thermal Power Plants, Pulp & Paper, Textile industries, Steel, etc. has been quite significant, adding further pressure on the industrial water demand. Many of the Thermal Power Plants in India are located in the water scarce regions (Luo et al., 2018). Despite an increasing and competing water demand amongst various sectors, the water use in different sectors in India remains inefficient. Indian industries consume relatively higher amount of water for production as compared to international standards, while their water productivity in terms of ratio of water consumption to economic value creation is low, as compared to many developed nations. It is estimated that without water efficiency improvements, global water demand will exceed available supplies by 40% by the year 2030 (2030 Water Resources Group, 2009; UNEP, 2014). It is thus imperative for all the sectors including industries to integrate the strategies on water demand management, enhancing water use efficiency, water conservation, recycle and reuse, etc., to address water scarcity and water demand supply gap.

The Government of India under its National Water Mission (NWM) aims to conserve water, reduce wastage and ensure its more equitable distribution across and within States through integrated water resources development and management, besides a goal to develop a framework for optimizing water use efficiency by 20%. This would be possible only by various sectors including industrial sector focusing on optimization and improvement of their water use efficiency. Although attempts are being made to promote sustainable water practices in industries to ensure efficient use and minimize the adverse impact on environment, there has been a need for a national guideline framework for setting up water use benchmarks in Indian industries. In the absence of an established national guideline or sector specific benchmarks on industrial water use, the implementation of water conservation and efficiency interventions remains an open-ended vision without any sector specific targets to follow and aspire for.

This policy brief aims to review the current water use practices in water intensive industries (viz. Thermal Power Plants, Pulp & Paper, Textile and Iron & Steel) and attempts to facilitate the setting up of the potential benchmarks for water use in water intensive industries in India through identified water saving interventions as well as technical and policy recommendations. It would serve as a guiding roadmap for these industries in attaining the goal of improving water use efficiency.

[1] A condition when per capita water availability falls below 1000m3

1.1 Water intensive industries in focus

Some of the major water intensive industries in India include the thermal power plants, heavy engineering, textile, pulp & paper, steel, sugar, fertilizer etc. Although the water consumption in various industries varies based on their individual processes and water use practices, it is significantly higher in the thermal power plants (> 80%) as compared to the other industrial sectors (refer Figure 1a). This policy brief shares insight based on the evaluation of four water intensive industrial sectors viz. Thermal Power Plants, Pulp & Paper, Textile and Iron & Steel. The assessments are based on available secondary data in public domain as well as comprehensive field water audits conducted by The Energy and Resources Institute (TERI) in selected number of these industrial sectors with representative range of production capacities, raw materials and processes etc.

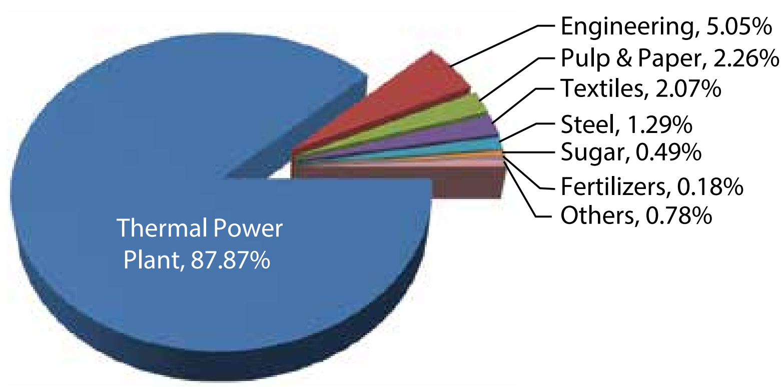

Figure 1a. Water consumption in Indian industries[2]

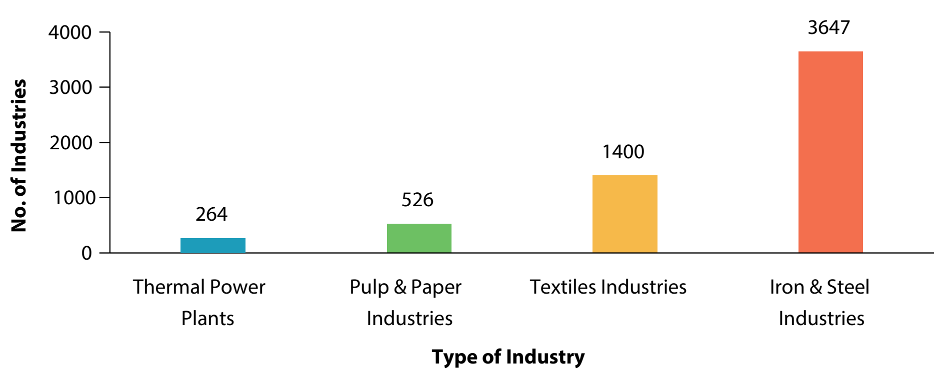

Figure 1b. Water intensive industries in India[3]

Based on the assessments, a range of potential water savings interventions were identified for each selected industrial sectors to reduce their specific water consumption that formed the basis for establishment of achievable water use benchmarks for these industries.

2. State of water use in selected water-intensive industries

The volume of water used in various processes of different industrial sectors differ across their plant operations due to several factors like input raw materials, manufacturing processes, equipment/technology variations,

[2] CSE based on the wastewater discharged data published by CPCB in "Water quality in India (Status and trends) 1990 - 2001"

[3] Source: Total number of thermal power plants (Ministry of Power, 2023), pulp & paper industries (Indo German Energy Program, 2021), textiles industries (GARTEX texprocess India, 2023), iron & steel industries (Ministry of Steel, 2011).

age of the facility etc. This section presents the key areas of water use in respective industrial sectors with a broad range of the Specific Water Consumption (SWC) as a metric of industrial performance, representing the total amount of water consumed per unit of the product.

2.1 Thermal Power Plants

The power generation industry is globally comprised of thermal, hydro and nuclear power plants. Water consumption is significantly higher in coal-based thermal power plants which uses significant amount of water constantly for cooling purposes (to cool the hot water received from the condensers), ash handling (transportation of ash to ash dykes in slurry form), steam generation (de-mineralized water) and sundry other uses including drinking, coal handling, service water, fire-fighting etc. (refer figure 2). Table 1 presents the observed range of Specific Water Consumption (SWC) in different capacities of thermal power plants. It may be noted that the SWC for the thermal power plants ranged between about 1.9 m^3/MW to 6.5 m^3/MW[4], representing the water consumption in the range of about 1179 m^3/h to about 13694 m^3/h for the studied categories of plants below 1000 MW, 1000 MW to 2500 MW and more than 2500 MW. The variations in water consumption were reflective of the type of cooling systems (e.g. open or closed cycle systems), ash handling practices and sundry other process and efficiency variations within the power plants.

2.2 Pulp & Paper Industries:

Pulp & Paper industries require significant amount of water during almost all the stages of paper production including, raw material preparation, pulping, bleaching, washing, paper making and finishing etc. (refer Figure 3). Globally, wood based and waste paper-based mills have water consumptions in the ranges of 50-75m^3/tonne and 10-25m^3/tonne respectively.[5]

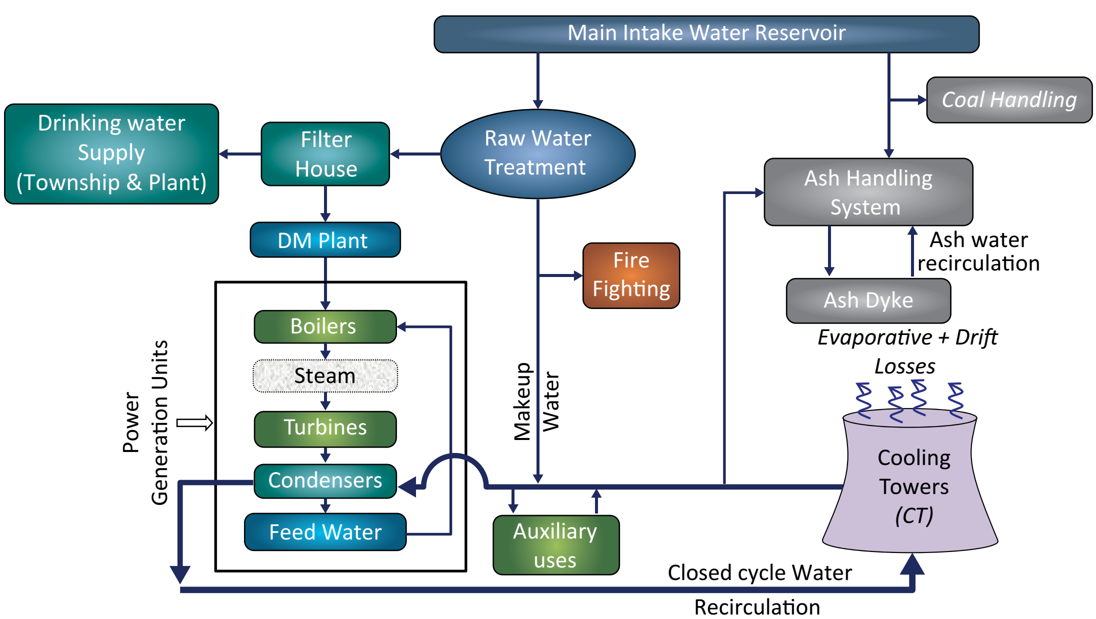

Figure 2 Processes & water usage areas in a thermal power plant

[4] The high SWC was observed due to the open cycle cooling system in some of the thermal power plants in this category during the study period.
[5] Green Rating of Pulp and Paper Sector, CSE.

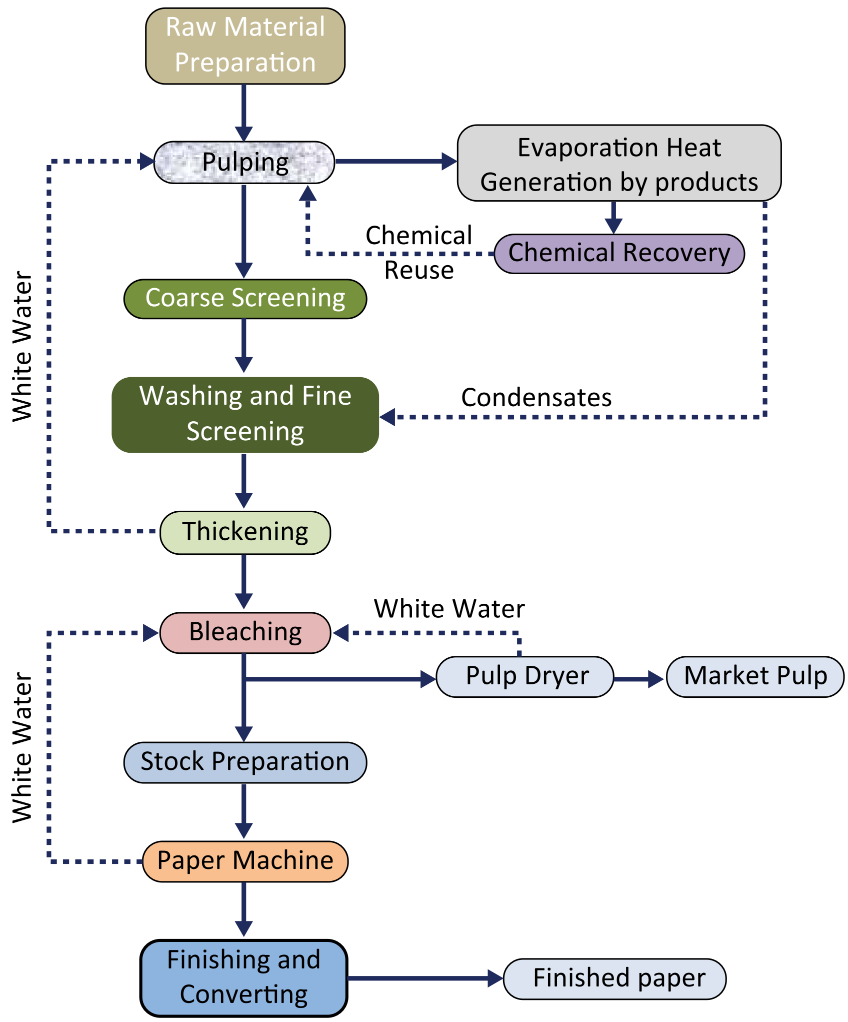

Figure 3 Processes & water usage areas in a pulp & paper industry

A considerably higher amount of water is consumed especially in the processes of pulping & paper making. It was noted that in the Integrated Mills, water consumption was considerably higher (between about 30 to 33 m^3/MT) (refer Table 1), as compared to the Recycled Fibre (RCF) based Mills (with water consumption between about 9.9 to 13 m^3/MT) due to the fact that unlike Integrated Mills which involves pulping (requiring significant water), RCF based Mills does not require pulping as they use recycled material which does not require virgin pulp. In terms of the quantum of water consumption, the observed range varied significantly lower (between 1770 m^3/day to 9959 m^3/day) in RCF-based mills as compared to the Integrated Mills ranging between 14014 m^3/day to 44318 m^3/day.

At present, 73% of the paper is produced from the RCF based mills while only 18% production is from wood based mills and remaining 9% is from agro based mills. The scenario was almost reverse in the year 1970, when production from wood based industries was the highest i.e., about 84% and RCF was minimum i.e., about 7%. To that, the Pulp & Paper industries have come a long way in reducing their water consumption compared to the historical consumption values. However, with advancement in technologies and best practices, significant opportunities exist in the sector for further improvement in water use practices as discussed in subsequent sections.

2.3 Textiles Industries:

Water in the textile industry is required in all the 'wet processes' such as washing of raw material, spinning, bleaching, dying, printing, finishing, cooling, DM water, multiple flushing procedures etc., which uses a significant amount of water to manufacture the cloth (refer Figure 4). Besides these, water is also used for drinking, fire-fighting and sundry purposes. By applying multiple best practices, various industries around the world keep their water consumption below 100m³/tonne of cotton[6]. Table 1 presents the existing range of SWC for the Integrated industry (cotton), Fabric Processing Units (cotton) and Integrated Woolen Industry. The observed range of SWC for fabric processing units were lower (about 51.1 – 97.5 m³/MT) as compared to integrated industries (cotton) (104.1 – 343.5 m³/MT) and integrated industries (woollen) (237.1 m³/MT) as they have many more processes. In terms of the quantum of water consumption, the observed range varied from 5625 m³/day to 5720 m³/day in integrated mills (cotton), whereas it varied between 271 m³/day and 877 m³/day for fabric processing mills as well as about 3555 m³/day for the integrated woolen industry.

2.4 Iron & Steel Industries:

Iron and Steel industries uses water mainly in the process of cooling, coke quenching, reactor cooling in the Blast Furnace, Electric Arc Furnace, basic oxygen furnaces, ladle treatment continuous caster and hot rolling (refer Figure 5), apart from the requirement for domestic purposes. India is not only the 2nd largest producer of steel in the world but also the largest producer of sponge iron. The observed range of water usage in Iron & Steel plants fluctuates based on production and it ranged between 6874 m³/day to 59682 m³/day with SWC ranging between 5.3 – 7.7 m³/MT for the studied plants (Table 1).

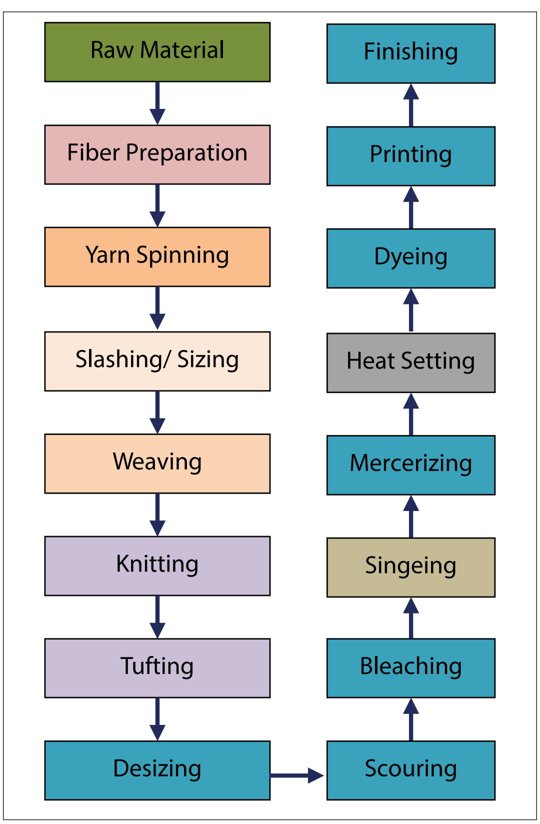

Figure 4 Processes & water usage areas in a textiles industry

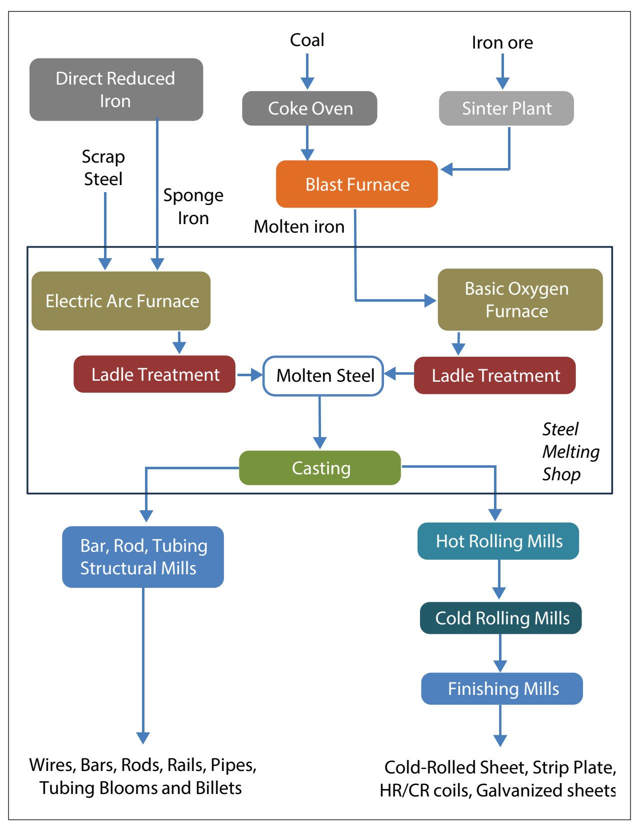

Figure 5 Processes & water usage areas in an iron & steel industry

6 Environmental management in selected industrial sectors - status and need, CPCB & MoEF, February, 2003.

3. Water Savings Interventions and Potential Benchmarks

A combination of technical assessments, field water audits, stakeholder consultations and inputs from the relevant industries revealed significant opportunities for water savings that can enhance the water use efficiency in these industries considerably. The assessments also revealed that a few of the studied industries had a considerably efficient existing water use while many others had a significant scope for improvement. This section highlights the key identified interventions and existing best practices for water intensive industries to reduce their specific water consumption along with the identified potential benchmarks that marks the first step towards setting up of the guidelines for benchmarking water use efficiency for water-intensive industries in India.

3.1 Key Opportunities for Water Savings

3.1.1 Thermal Power Plants:

Depending upon their capacities and stage of operations, Thermal Power Plants can save significant volume of water through following key water saving interventions.

- **Cooling System:** Increasing the cycle of concentration (CoC)[7] (up to 6) in Cooling System. Shifting from wet cooling to dry cooling systems where it is feasible. Shifting to closed-cycle cooling system from once-through cooling system (where still not done).
- **Ash Handling System:** Increasing recirculation[8] (~70%) of water from the ash dykes in Ash Handling System. Adopting high concentration slurry disposal (HCSD) system. Shifting from wet ash handling to dry bottom ash handling (Hyrdobin based Ash Handling).
- **Wastewater Recycle/Reuse (Zero Discharge):** Almost entire wastewater could be treated and recycled/reused for various processes within the plant thus moving towards zero discharge.
- **Others:** Rationalizing the township drinking water supply as per the norms. Plugging the visible leakages/losses & avoiding the fresh water use for sundry uses in fire system. Increasing the operating temperature and pressure i.e., the steam parameters (supercritical power plants). Using technologies like cogeneration, IGCC (Integrated Gas Combined Cycle), and direct firing of gas turbines with coal. Retrofitting or replacements (e.g., boilers).

3.1.2 Pulp & Paper Industries:

Based on the process of the paper manufacturing, following are the identified key interventions for water saving in Pulp and paper industries

- **Pulp Mill:** Dry debarking-process water is used only for log washing. Dry debarking results in bark with lower water content. **Improving pulp washing technology** such as using twin wire roll press washer, belt washing, etc. **Deinking Process** such as flotation deinking process where small air bubbles are used to remove ink from the pulp or utilizing membrane filtration in de-inking plant. New technologies like **flash condensing steam** and **Dry Pulp** for cure formed paper offer potential for near waterless, or waterless, production.
- **Paper Making: Process water recirculation: Save-all Clarification System:** The overflow of white water from paper machine post stock dilution is clarified in saveall clarifier and can then be used in mill applications for adjusting stock consistency and substitution of fresh water for e.g. paper machine showers. **Poly Disc Filtration System:** Liquid is forced through the filter layer by applying a vacuum and the clear

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7 CoC can be increased by using chemical treatments (anti-sludging, anti-sepsis, acidification, etc.) and by regular maintenance of the cooling towers.

8 Ash water can be recycled where possible such as for ash handling, gardening, fire-fighting and dust suppression in the coal stacking yard.

filtrate can be used in paper machines while the cloudy filtrate is readily re-used in machine broke pulping and stock dilution. Reduction of nozzle size of showers in paper machines saves significant water. **Use of single jet scanning showers** in cleaning showers in paper machine can significantly reduce the required water flow. **Recirculation of sealing water**.

- **Wastewater recycle/reuse (zero liquid discharge-ZLD):** SPCB (State Pollution Control Board) Statutory mandates for all pulp & paper mills to attempt to move towards ZLD.

3.1.3 Textiles Industries:

The range of key water saving interventions for textile industries include

- **Reuse and recycle wastewater (zero discharge):** treated wastewater can be reused in processes such as printing, rinses of scouring, washes of dyeing, etc.
- **CIM (Computer Integrated Manufacturing):** Washing machine can be replaced with highly efficient CIM (Computer Integrated Manufacturing) machines.
- **Use of Counter current washing in continuous wet process:** This reduces the water consumption with few modifications of the existing system. For e.g. in wool processing, counter current washing can reduce the water quantity by up to 60 KL/MT of wool.
- **Use of upgraded technology:** Use of automatic shut-off valves – valves set to time, level or temperature that controls the flow and saves water.
- **Adopting water efficient dyeing technologies** such as cold pad batch technology for dyeing, others like winch dyeing, beam dyeing, jig dyeing, etc.
- **Other Reuse and recycle opportunities in the process:**
  - **Recycle/reuse of cooling water and condensate water** as boiler feed water
  - **Reuse of process water from rinsing operations of wet process:** E.g. - final rinse water from one process can be used for the first rinse of another process
  - **Reuse of process water from bleaching and mercerizing:** E.g., reusing mercerize wash-water or bleach wash-water for scouring.

3.1.4 Iron & Steel Industries:

The range of identified key water saving interventions in Iron & Steel sector includes the following

- **Coke Dry Quenching (CDQ):** CDQ is a system where hot coke removed from coke ovens is cooled and kept dry with inert gas and the resulting steam produced in a waste heat recovery boiler is used to generate electricity. In addition CDQ reduces dust emissions and improves of coke quality.
- **Recycling and reuse of Cooling Water** after chemical treatment e.g. in steel melting shops. Utilizing cooling tower blow down in Mills & Steel melting shops and as make up water for furnace gas cleaning in Steel Plant. Strengthening Cooling System in Coke Oven (e.g. improve performance of heat exchangers, reduce drift losses, effective cooling)
- **Use of dry gas cleaning system** for basic oxygen furnace or submerged arc furnace instead of wet gas cleaning system
- **Reuse and recycle of wastewater:** Almost entire wastewater could be recycled/reused to move towards zero discharge. E.g. as make-up water in Cooling Systems and soft water systems
- **Optimizing the design and placement of spray nozzles** have a potential to reduce water consumption by around 10-20% .
- **Water Spray Dry Cooling (WSDC):** A technique for reducing once-through cooling water in continuous steel casting process, WSDC utilises internally-cooled rollers, which provide heat withdrawal due to the direct contact between the rollers and the hot metal.

3.2 Potential Benchmarks

Establishing water-use benchmarks across various industrial sectors is a much-needed intervention to serve as a reference point and guiding roadmap for industries to enhance industrial water-use efficiency. It would also help as a platform for knowledge sharing and inclusive water management for industries within and their value chain.

Based on identified opportunities and industrial stakeholder consultations a set of select interventions having feasibility of adoption were shortlisted and were further categorised as the short-term and long-term where applicable. Further, an estimate of applicable water saving potential and associated potential benchmarks were established for each of the studied water intensive industrial sectors. Section below highlights the key shortlisted water saving interventions for each sector and Table 1 further presents the estimated potential benchmarks in each of the selected industrial sectors for the short-term as well as long-term.[9]

Thermal Power Plants:

Short term interventions:	Recirculation (~70%) of water in Ash handling system; increasing the CoC (up to 6) in Cooling System, and reuse/recycle of wastewater (zero discharge)
Long term interventions:	Switching from wet ash handling to dry ash handling system and Shifting from conventional wet cooling to dry cooling system

Pulp & Paper Industries:

Short term interventions:	Reduction of nozzle size in Paper Machine and reusing at least 50% of the wastewater being discharged from the mill *(while most of the Integrated Mills were already reusing about 50% of their wastewater, RCF mills were yet to adopt this intervention in a significant manner)*
Long term interventions:	Reclamation of processed water (Saveall Clarification System and Poly Disc Filtration System) along with approaching ZLD

These interventions promised substantial water savings in both the categories of the mills.

Textiles Industries:

Significant water savings can be achieved through interventions such as

- Recycle and reuse of wastewater as well as
- Replacing the existing washing machines with highly efficient Computer Integrated Machines (CIM).

However, a few opportunities exist within the processes, such as reusing water from pre-treatment processes, reusing final rinse water from dyeing for dye bath makeup, etc., which could as well be adopted to achieve immediate water savings.

Iron & Steel Industries:

Water-saving interventions that hold significant potential include

[9] It may be noted that these potential benchmarks are indicative in nature and are meant to highlight the opportunities that exist for enhancing water use efficiency in the industries. These can serve as a guiding platform for formulating specific action with further updated knowledge and data.

- Switching to Coke Dry Quenching (CDQ) and
- Reusing/recycling wastewater.

These interventions are, although cost-intensive but, can be very effective in improving the water use efficiency in the iron & steel plants.

Table 1 Existing Specific Water Consumption & Potential benchmarks for different industrial sectors

Industry	Sub-industry type	Existing Specific Water Consumption (SWC)	Achievable Benchmark SWC	
			Short-term interventions	Long-term interventions
Thermal Power Plants (m3/ MW)	Small (Up to 1000 MW)	2.3 - 3.9	1.5 – 3.4	0.5 – 2.7
	Medium (Between 1000 to 2500 MW)	1.9 – 6.5	1.3 – 3.0	0.3 – 1.6
	Large (2500 MW and more)	3.0 – 3.2	1.5 – 2.0	0.6 – 1.7
Pulp & Paper (m^3/MT)	Integrated Mills	30.5 – 33.0	29.2 – 32.2	13.0 – 14.5
	RCF based Mills	9.9 – 13.0	7.1 – 9.9	4.0 – 7.8
Textiles (m^3/ MT)	Integrated Industry (cotton)	104.1 – 343.5	104.1 – 182.5	
	Fabric Processing Industry (cotton)	51.1 – 97.5	51.1 – 74.0	
	Integrated Industry (woollen)	237.1	185.6	
Iron & Steel (m^3/MT)	Iron & Steel	5.3 – 7.7	3.9 – 6.1	

3.3 Benefit-Cost of select interventions

Benefit cost scenario will vary significantly based on the nature and type of interventions, associated costs and actual water use practice of an industry. However, rough estimates indicate that there can be considerable financial benefits of the identified interventions in the industrial sectors.

For example, in thermal power plants, identified interventions like ash water recirculation enhancing the CoC and implementing wastewater recycling/reuse can lead to substantial cost savings, offering attractive financial advantages and favorable payback periods. A rough estimate indicates that adopting these short-term interventions can yield a collective average monetary benefit of about INR 30 crore/year with an accompanying water savings of nearly 10 million m^3/year.[10] Similarly, in pulp & paper industries, adopting interventions such as nozzle size reduction in jet showers and process water reclamation through poly disc filtration systems reflects considerable water savings in a very short period. The technology of poly disc filtration has a payback period of less than 2 years in integrated mills and about 8 years in RCF-based mills.

In the textiles industries, interventions like counter current in wet processing, adoption of CIMs, and reuse/ recycle of wastewater can bring down the specific water consumption significantly while also having some financial benefits. Similarly, for the Iron & Steel industries, adopting intervention of CDQ although can be costly but can lead to huge financial savings with attractive payback period. The major source of savings in these comes from electricity generation and reduction in coke consumption in Blast Furnace.

[10] It may be noted that these are indicative figures and the benefit cost may vary considerably depending upon various factors including variation in input cost and actual water savings.

Although the financial savings for some of the selected interventions are quite significant, with appropriate water tariffs for the industrial sector, these savings could be enhanced further. Moreover, the rational pricing of water will drive industries to become more water efficient and conserve water by adopting better practices & technologies.

3.4 Government initiatives for water-intensive industrial sectors

In light of the various ongoing initiatives by the government, it may be worth mentioning the intervention that have facilitated the improvement in water use efficiency in Indian industries.

- For thermal power plants, as per the existing guidelines, plants that are and will be commissioned after 2017 need to undertake the following:

Plants before 2017	Plants after 2017
Medium COC	High COC (mandatory to retain 5)
Lean Slurry	High Concentration Slurry
No or Minimal Ash Water Recirculation	No Recirculation Required
Low Cooling Tower Blow-down Recovery Potential	High Cooling Tower Blow-down Recovery Potential

Additionally, new plants installed after 2017 need to meet a specific water consumption of 2.5 m^3/MWh and achieve zero liquid discharge (CPCB, 2017).

- For the pulp & paper industries, several efforts from CPCB resulted in huge freshwater savings and a decrease in wastewater generation by pulp and paper industries in the Ganga basin **(Figure 6)**.

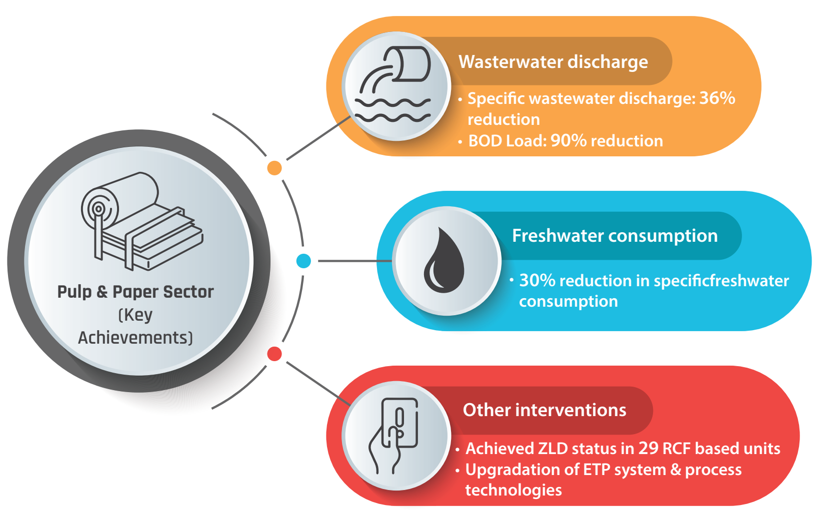

Figure 6 Key achievements of the Pulp & Paper industries in the Ganga Basin

- Similarly, in the textiles sector, initiatives by CPCB led to a reduction in freshwater consumption as well as wastewater discharge, as shown in **Figure 7**.

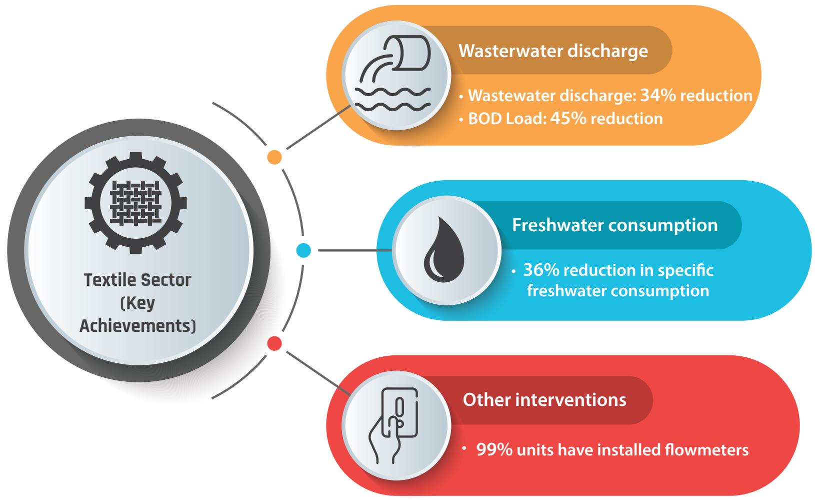

Figure 7 Key achievements of the Textiles industries in the Ganga Basin

- For iron & steel plants, India follows the standard given in "PM Steel Trophy for excellence of Steel plants". Water uses of Iron and steel plants with a minimum production capacity of 1 million TPA are considered for the award. The water use, excluding consumption for the township, power plant, oxygen plant, rolling mill, and tube mill, is considered for SWC calculation. The target SWC is kept as 2 m^3/tcs with a cut-off of 6 m^3/tcs.

4. Key Recommendations

Indian industries have a significant role to play for enhancing water use efficiency and ensuring water security in India. As evident from the previous sections, there exists significant opportunities in water intensive industries in India to save water and enhance their water use efficiency, while ensuring water sustainability within their operations and the value chain besides contributing to the goals of the National Water Mission and the SDG-6. Following section highlights some of the key technical and policy recommendations based on the study

4.1 Technical Recommendations

Sector-wise recommendations for reducing Specific Water Consumption

Section 3.1 of this policy brief details out some of the key technical interventions that holds immense potential for reducing the specific water consumption of the selected water intensive industries. A summary of the sector-specific recommendations is presented in **Figure 8**.

Apart from these sector-specific interventions, there are a bundle of practices/interventions that can be adopted across all sectors to improve their water use efficiencies; these are:

- **Optimizing township water supply** (wherever the industry has a township in its vicinity)
  The volumetric water supply in the township should be rationalized (to near 135 lpcd or 255 lpcd max) (BIS, 1993 & CPHEEO, 1999), and the sewage water from the townships should also be considered a resource and reused within the plant or residential premises.

Thermal Power Plants

- **Ash Handling Process**
  - Increasing recirculation rate of water from the ash dykes
  - Switching to high concentration slurry disposal system (HCSD)
  - Shifting from wet ash handling to dry ash handling
- **Cooling System**
  - Increasing the CoC (up to 6) in Cooling System
  - Wet cooling to dry cooling systems where it is feasible
  - Shifting to closed-cycle cooling system from once-through cooling system
- **Wastewater reuse/recycling** (zero discharge)

Pulp & Paper Industries

- **Pulp Mill**
  - Dry debarking
  - Improving pulp washing technology such as using twin wire roll press washer, belt washing, etc.
  - Utilizing membrane filtration in de-inking plant and improving technology of de-inking plant
  - New technologies like flash condensing steam and Dry Pulp
- **Paper Machine**
  - Reduction of nozzle size in paper machine
  - Recirculation of sealing water
  - Turbo air blowers
  - Process water recirculation:
  - Save all Clarification System
  - Disc Filtration System
- **Wastewater reuse/recycling** (zero discharge)

Textiles Industries

- **Washing machine replaced with highly efficient CIM machine**
- **Use of Counter current washing in continuous wet process**
- **Opportunities in pre-treatment and dyeing process**
  - Reuse and recycle of pre-treatment process water
  - Adoption of cold pad batch technology for dyeing, and others like winch dyeing, beam dyeing, jig dyeing, cheese dyeing, etc.
- **Wastewater reuse/recycling** (zero discharge)

Iron & Steel Industries

- **Coke Dry Quenching**
- **Dry gas cleaning system for Submerged Arc Furnace (SAF)**
- **Considering emerging technologies**
  - The latest emerging technologies like Water Spray Dry Cooling (WSDC)
  - Optimizing nozzle design & placement
  - Using nano-fluid mix for casting
- **Wastewater reuse/recycling** (zero discharge)

Figure 8 Sector-wise water-efficient practices/ recommendations

- **Regular water audit**
  Water audit is an effective management tool for minimizing losses, optimizing various uses and thus enabling considerable conservation of water. Regular water audits must be internalized by the industries under a corporate water policy framework.
- **Automation and real-time water (flow & quality) monitoring**
  The introduction of an automated water quality and flow rate monitoring system in a plant can reduce human error during measurements. Holistic supervision of respective parameters can be maintained through adequate metering and a centralized control & database management system along with an established management information system (MIS). Real-time water quantum/flow monitoring must be undertaken for better understanding of water balance and leakage/losses in the system, while real time water quality monitoring can ensure water quality compliance, besides identifying opportunity for recycle/reuse of wastewater based on quality.
- **Upgrading the technology**
  Latest technological innovations and upgradation must be adopted regularly for an efficient operation and manufacturing process that besides enhancing production capabilities also provides co-benefits of saving energy and water.
- **Water conservation and Rainwater harvesting**
  Industries must adopt comprehensive rainwater harvesting practices within and outside their premises (i.e. watershed) to enhance the water availability for themselves and within the regional watershed.

4.2 Policy Recommendations

In view of the challenges in the water sector and the identified sector-specific interventions for enhancing water use efficiency, the following policy recommendations are suggested:

- **Setting up of Water Use Benchmarks for Industries:** In absence of a clear standard for water use and in order to facilitate improvement in industrial water productivity, there is a need to provide the industries with a set of clear guidelines and identified benchmarks that would serve as a roadmap for them in attaining the goal of improving water use efficiency. Thus, appropriate benchmarks need to be set for industrial water consumption after taking technical feasibility and socio-economic factors into consideration. These benchmarks would assist the regulatory authorities in defining policy objectives and monitoring the progress towards the defined goals and targets. This study and its recommended range of water use benchmarks can serve as an initial guideline to initiate the setting up of benchmarks in a phase-wise manner for respective water intensive industrial sectors viz. Thermal Power Plants, Pulp & Paper, Textile and Iron & Steel industries.
- **BWUE to be given a legal status:** While the Bureau of Water Use Efficiency has been setup now, it may be given a legal status for enforcing compliance and implementation of the various identified policy interventions and programs including implementation of the identified benchmarks for water use efficiency and its updation from time to time.
  In this regard, the National Water Mission (NWM) can play role of central implementing agency by engaging the Central Pollution Control Board (CPCB), while water being a state subject, the SPCB (State Pollution Control Boards) can be assigned addition role of implementing such interventions at the state level.
- **Mandatory Water Audits from Third-Party Auditors:** A need for nationwide framework for mandatory third-party water audits - while government has initiated water audits, there is a need for establishing a national framework across the country for comprehensive regular water audits by third party institutions with transparent data & information sharing to enhance the water productivity and use efficiency. These audits will ensure the conformance of the benchmarks within the industry and also address the data gap in supply, demand and utilization of water by the industry. Mandatory regular third-party water audits

through policy directives would ensure a dynamic assessment of the water use efficiency in the sector and help in enhancing water use efficiency goals.

- **Information Management and Public Data Sharing:** The data shared by plants or mills regarding water use can suffice the needs of various studies and inform individual units about the best practices followed in the industry. Thus, it is important for industries to share data regarding water use with the government and the general public.
  It may be useful in this context for the government to establish a live dashboard (on the lines of the Jal Jeevan Mission) for industrial water use benchmarks, and other water use, water quality and discharge data in public domain for transparent sharing of information and best practices.
- **Industrial siting to be based on the carrying capacity of the region:** Given the overexploited state of several groundwater bodies and declining water table in several parts of the country, industrial siting must be allowed based on the carrying capacity of a region.

Recommendations for Water Pricing

- National Water Framework Bill 2016 suggested that water used for commercial agriculture and industry should be priced on a full economic pricing basis
- Draft Water Policy 2020 recommended that operation and maintenance costs should be fully recovered through water service fees
- Each state to form a Water Regulatory Authority, which could set up the tariff, and for industrial users, emphasis on recycling and reusing of water should form the underlining principle for the pricing of freshwater. Additionally, the tariff should be able to recover the O&M cost of water supply.
- There should be incentive mechanism by the water regulatory authority to provide incentives to those industries who adopt water neutrality approach.

Maharashtra Water Resources Regulatory Authority has the following provisions for industrial water users:

- Higher block tariffs for industrial users to promote optimum utilization of water and reduction in wastage
- Incentives for industries adopting recycling

Recommendations for wastewater treatment and reuse in industries

- The government could fix a specific amount of mandatory reuse of wastewater within industrial premises that could help enhance water use efficiency and reduce the stress on freshwater resources.
- For every industrial sector, a reliable and comprehensive database record needs to be created for present wastewater generation, treatment, technology options, challenges, gaps and end use of treated water.
- Funding agencies like Start-Up India Grants and Challenges, Invest India Fund, etc., should be encouraged to promote energy-efficient, cost-effective treatment technologies, including ZLD.
- The government can provide incentives for industries reusing and recycling wastewater in various ways, for example, by providing rebates on electricity charges, tax rebates etc. for those adopting cleaner and greener technologies.

- The government should encourage R&D work in wastewater treatment, recycling and reuse.
- Promoting and incentivising cross-sector usage of treated wastewater between different sectors, for example, between domestic and industrial sectors hold significant promise and should be promoted with supportive policies.
- Provide guideline framework and national wastewater reuse standards based on fit-for-purpose approach to promote wastewater reuse and resources recovery, besides incentive mechanisms that would help overcome bottlenecks towards last-mile connectivity of treated wastewater reuse. This recommendation would upscale and optimize wastewater reuse in industries.

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Notes

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