

Cooling Tower

Turbine

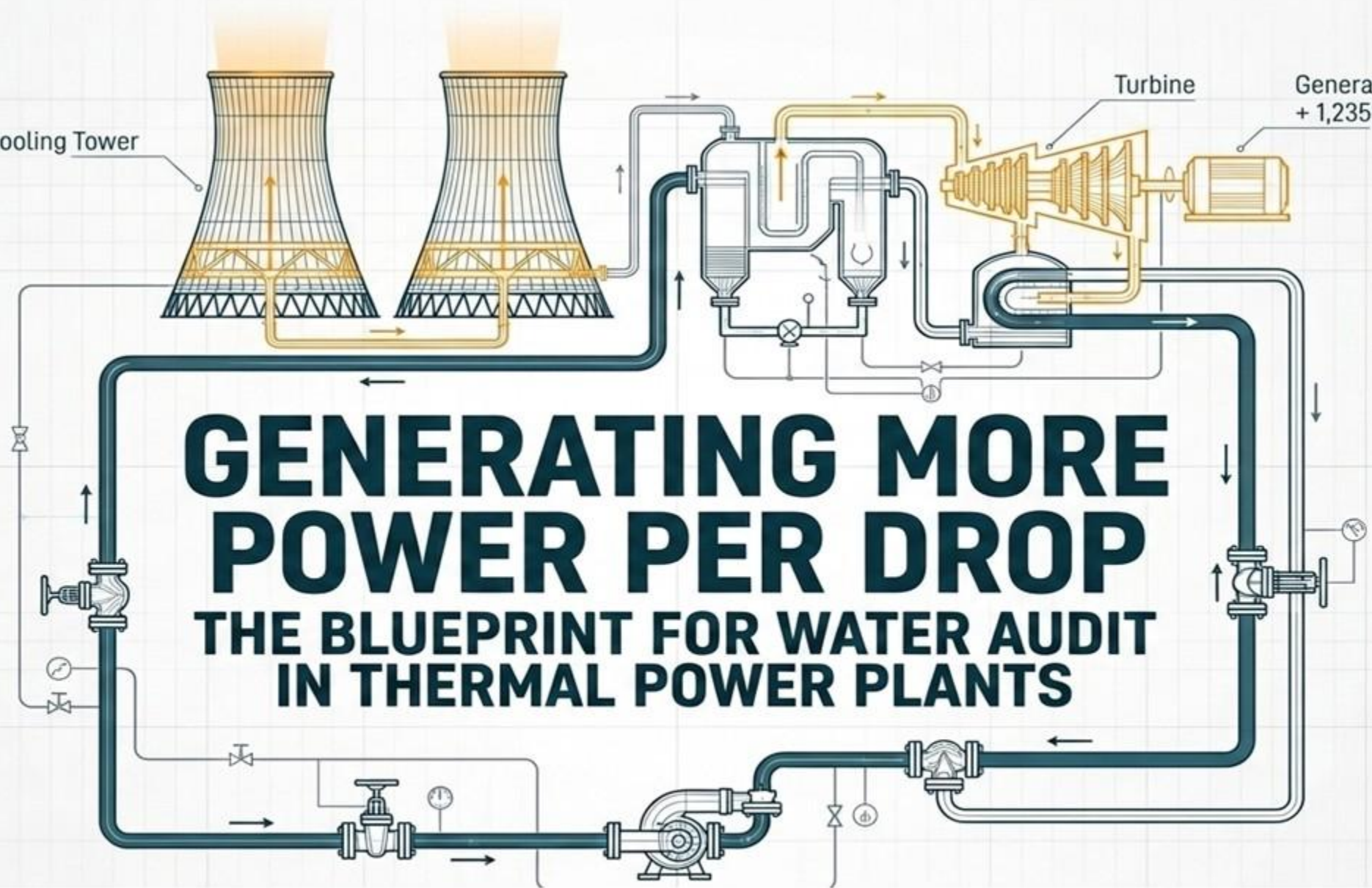
Generator
+ 1,2353 MkWe

GENERATING MORE POWER PER DROP

THE BLUEPRINT FOR WATER AUDIT IN THERMAL POWER PLANTS

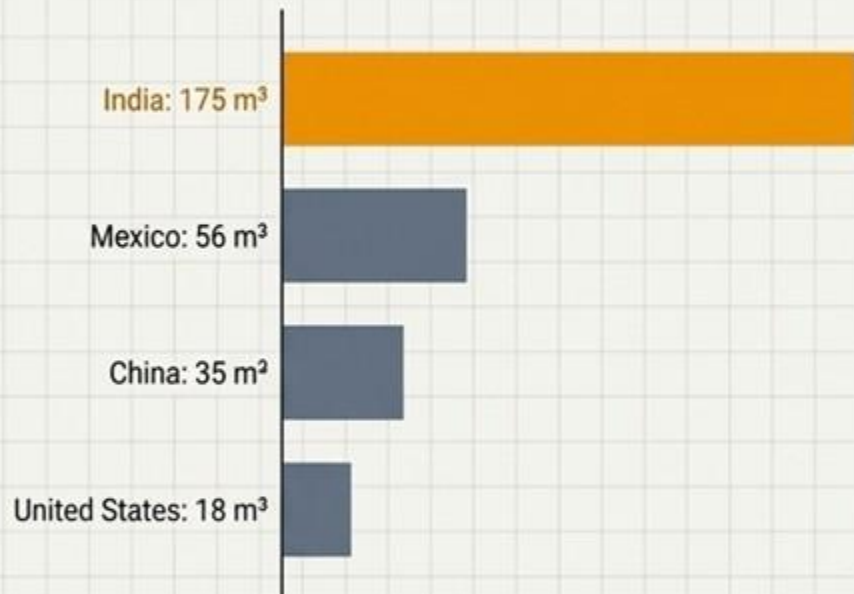
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The Macro Context of India's Water-Energy Nexus

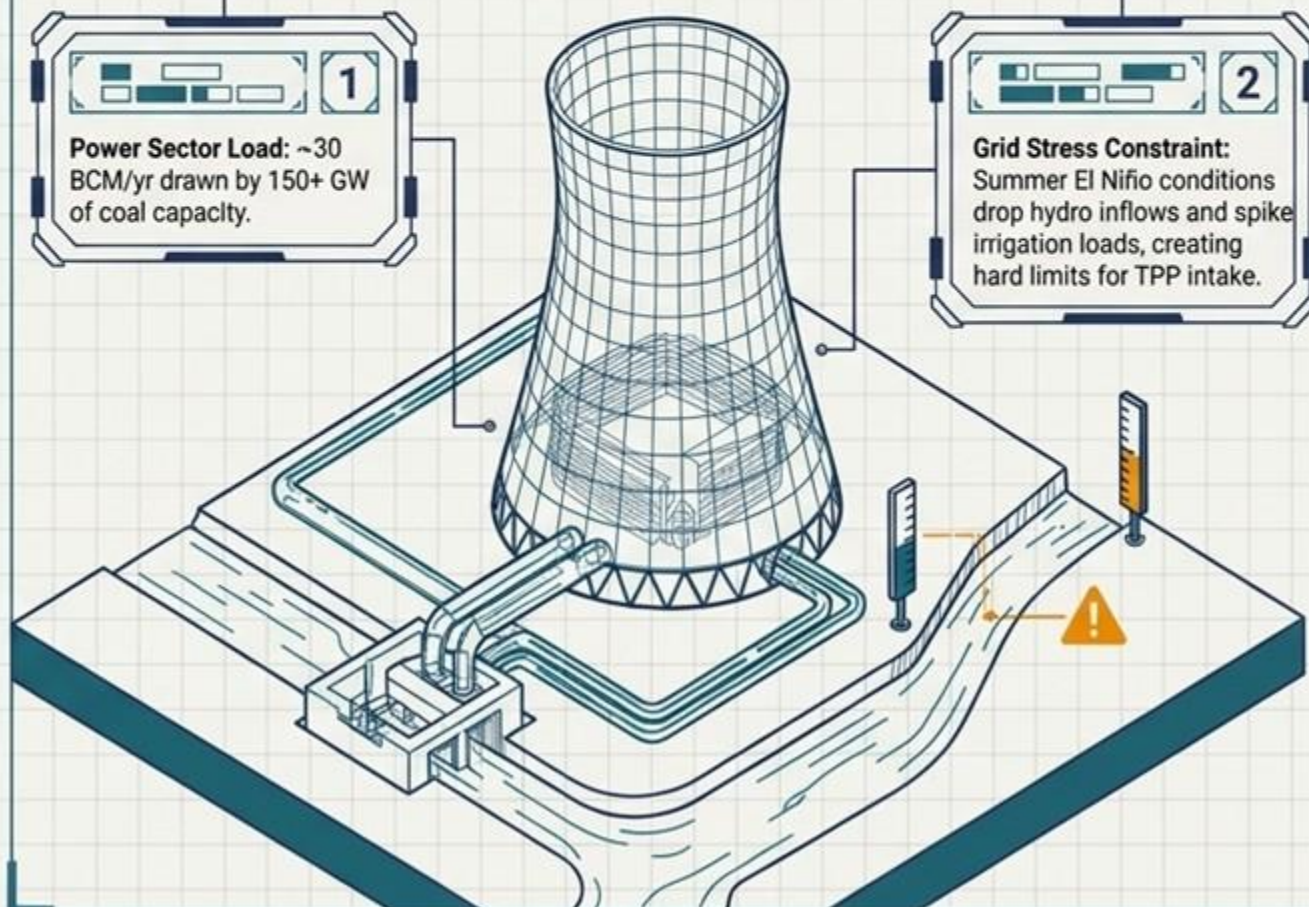
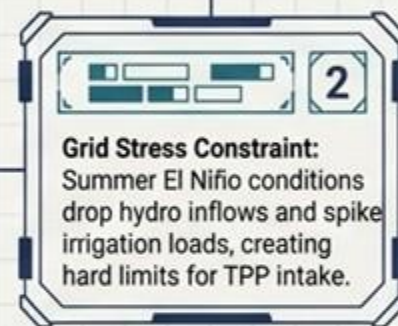
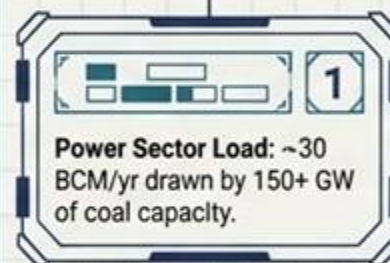
Global Water Use per \$1,000 of GDP (m³)



Total fresh water use: ~646 BCM annually.
India records the highest global water use per \$1,000 of GDP. **No Manufacturing of Water.**

88%

Share of industrial water consumption attributed to thermal power plants.



Implications for India's Water Security

Industrial Water Supply
Priority comes after Drinking
& Irrigation needs

40% of TPPs in High Water-Stress Areas
High withdrawals compress irrigation
windows, reduce reservoir flexibility.

Documented Farming-TPP Conflicts
**Maharashtra, Karnataka, Andhra
Pradesh**

Power plant cooling and crop
irrigation compete for the same
water — stress peaks simultaneously
in hot months. Power cooling
demand and crop water demand
peak **simultaneously** in summer —
compressing the same shared water
supply.

1000 MW is allowed to consume 31 MCM /year
Delhi Water Demand is 1500 MCM ~ 50 such Plants
200 GW Operational THERMAL
20 % WUE SWC 3.5 to 2.8 , 1.22 BCM can Return to Local River
Basins, ~ 5000 Cr./ year savings in Water Resources Development
Auxiliary Power Savings 0.5% ~ 0.5 MU/year ~ 22000 Cr/year

Water Efficiency in TPP
Plant-level water efficiency is both a
regulatory and **social equity** priority for
India.

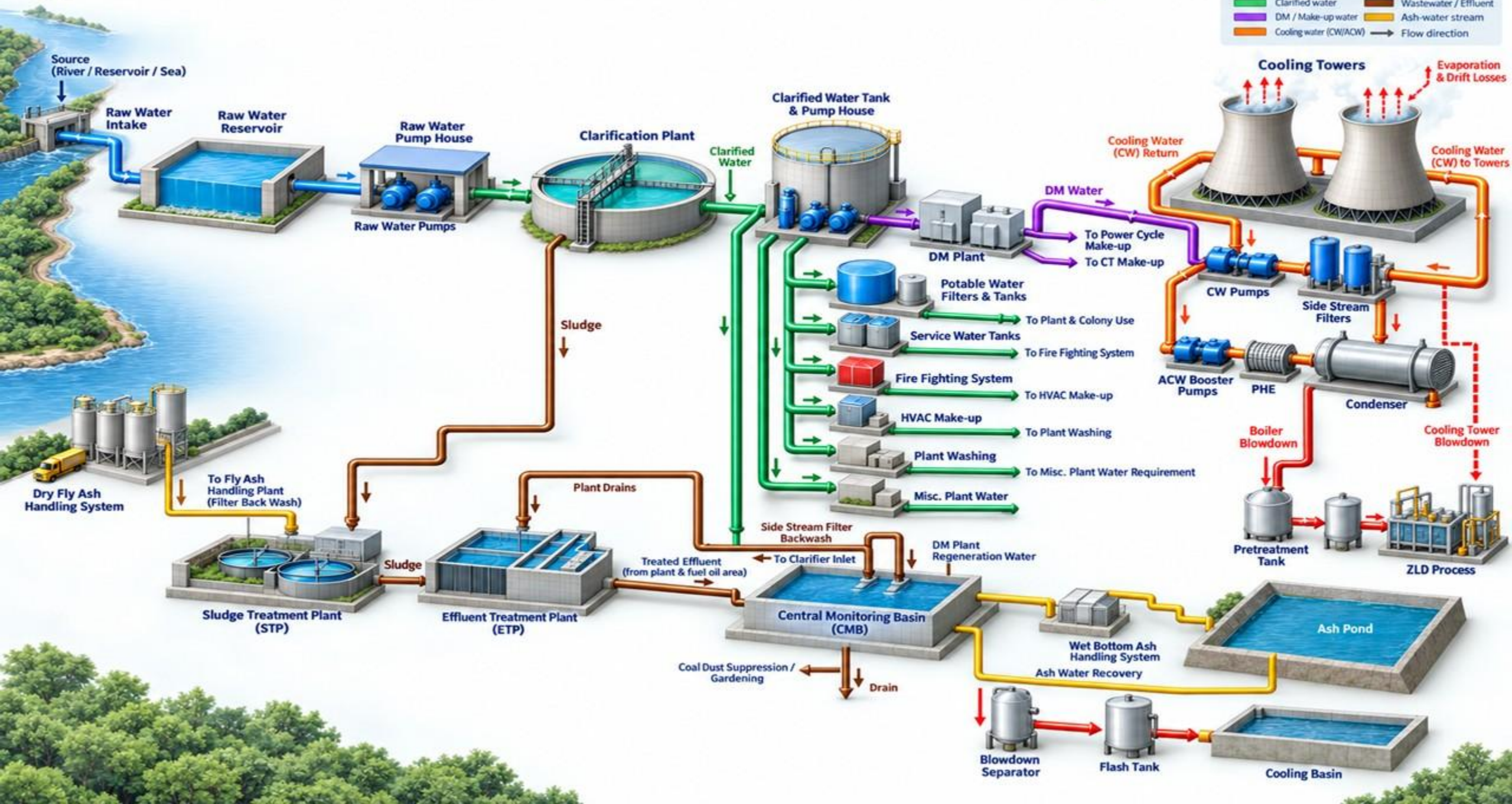
Water Audit Framework Sits in the Existing Law

Existing Statutes for TPPS	Provisions within the Statute
MoP: Electricity Act, 2003 — Section 73	Establishes CEA's technical-standards and data-collection mandate
MoP: Tariff Policy, 2016 (amendment)	Mandates use of Treated Sewage Water (TSW) for make-up within 50 km of a Sewage Treatment Plant, with cost pass-through.
MoEF&CC EP Act Norms (notified 7 Dec 2015, amended 2017, OM J-15011/01/2018-IA.I(T), dated 19 Nov 2018 — Annexure-I, Section F) New Plants (post 1 Jan 2017)	• Once-Through Cooling Plants, Must install cooling towers with 3.5 m³/MWh • Existing Plants Must reduce specific water consumption to 3.5 m³/MWh; • New Plants (Post Jan 2017) 2.5–3.0 m³/MWh, with mandatory Zero Liquid Discharge. • Upstream & downstream river flows logged daily, Daily Water Withdrawal Records, Environmental Flow — 15% of 120 days Lean Season as Environmental Flow, • Groundwater Quality Monitoring, Biannual monitoring near ash pond; heavy metals per CPCB norms • Effluent Recirculation & Zero Discharge, DM plant, boiler blowdown, ash pond effluents reused in-plant • Closed Cycle Cooling — COC ≥ 5 seawater COC ≥ 1.5 • Rainwater Harvesting • Condenser Discharge Temperature Release temp must not exceed intake + 5°C
Water (Prevention & Control of Pollution) Act, 1974	Underlies SPCB Consent to Establish / Consent to Operate conditions on withdrawal and discharge.

Typical Water Flow Network – 2 x 500 MW Coal-Based TPP (Wet Cooling Tower)

Legend (Water Streams)

→ Raw water	→ Blowdown / Losses
→ Clarified water	→ Wastewater / Effluent
→ DM / Make-up water	→ Ash-water stream
→ Cooling water (CW/ACW)	→ Flow direction



Thermal Water Footprint

Current Reality

333–400 kWh/m³ (5 lts for 1 kWh)

ASSUMPTION :Energy per unit water — typical Indian thermal plants today

Benchmark Target

360–450 kW/m³ (2.5 lts for 1 kWh)

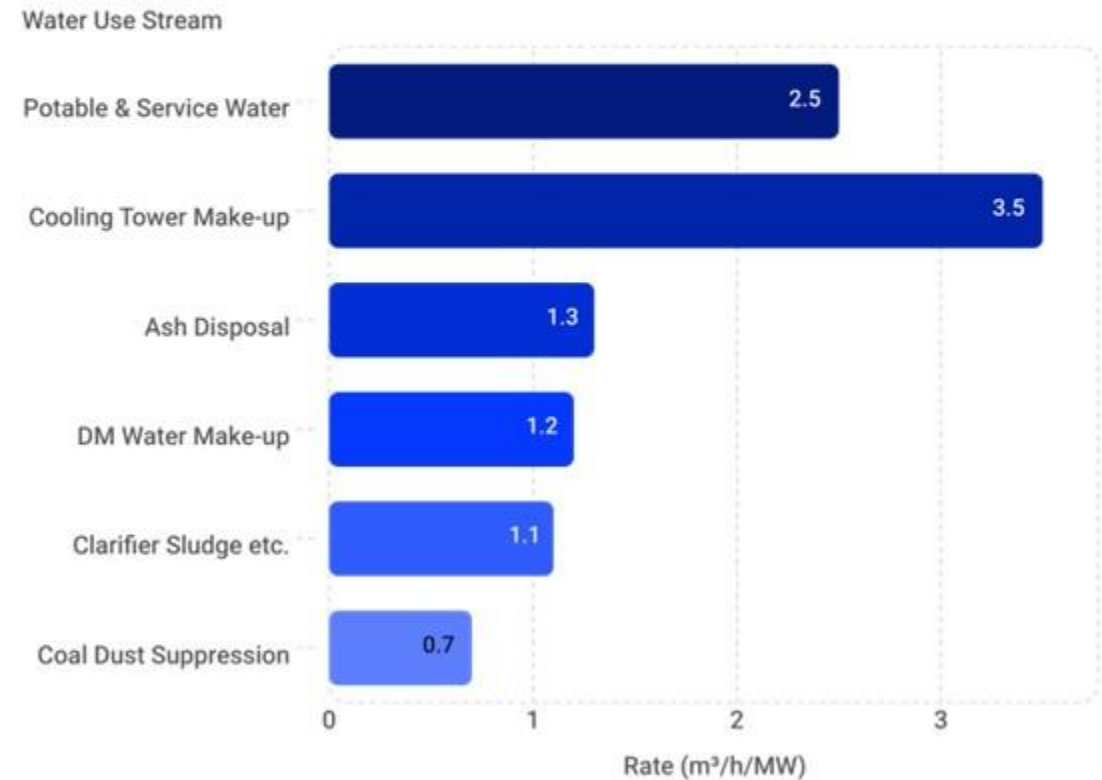
ASSUMPTION: Achievable with optimised operations & advanced treatment

GLOBAL STANDARDS 2.5 lts for 1 kWh

Breakdown of Water consumption Components

- Cooling Tower Makeup, Evaporation, drift & blowdown losses — largest component
- Ash Disposal, Slurry transport; high pump energy & water intensity
- Coal suppression, firefighting, DM plant & misc. uses
- Potable Water Heating, Township & plant domestic heating loads
- Ash Removal, Bottom & fly ash handling with water-intensive flushing

Observed Water Use — 2x500 MW Plant (m³/h/MW)



SWC Self-Reporting

SWC of **1.95 m³/MWh** proves savings well below 3 m³/MWh are achievable — benchmarks exist.

1. No Incentive for Accuracy Plants under-report to avoid regulatory scrutiny.

2. Non-Uniform Formats Varying inclusions make SWC figures non-comparable. Cooling tower alone exceeds 3.0 m³/MWh cap

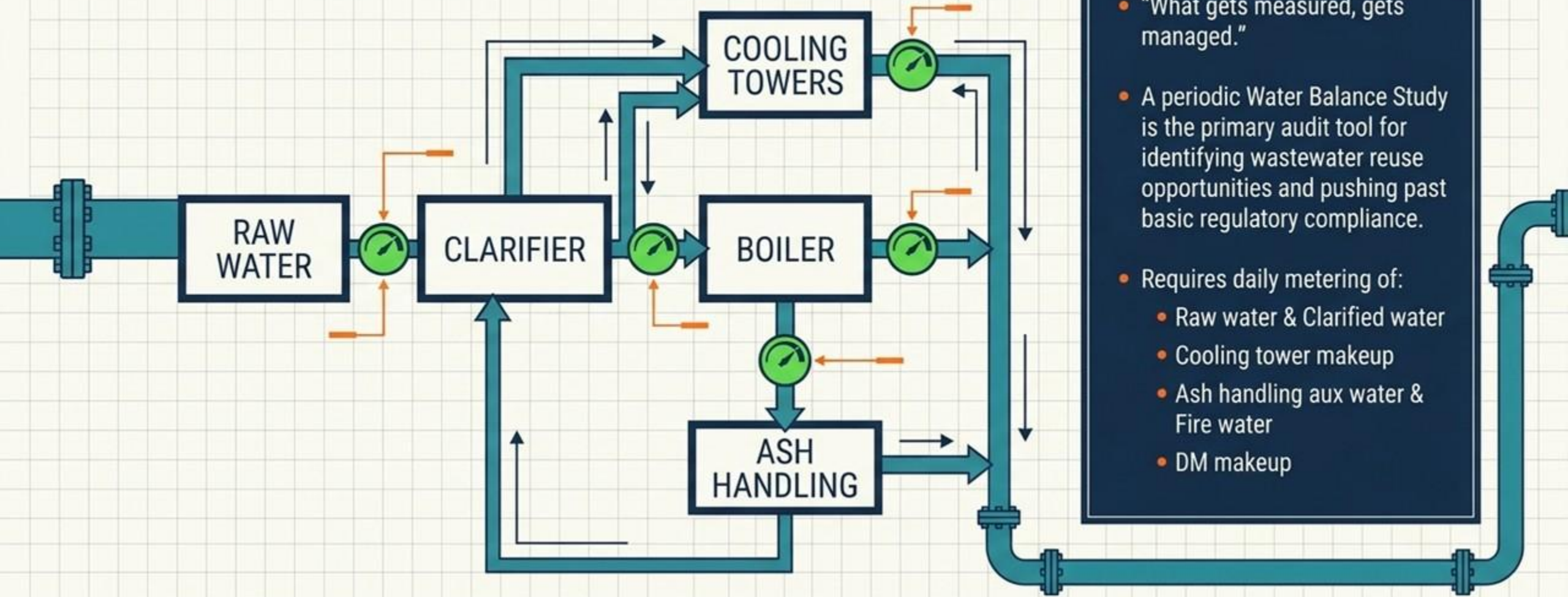
3. Poor Metering, Identical SWC values across units in one plant signals averaging, not measurement.

4. No Third-Party Audit, not independently verified.

5. Regulatory Blind Spots CEA lacks plant-wise data to validate SWC, Everything is based on ASSUMPTIONS
SWC compresses multiple variables into one ratio — plants appear compliant while hiding serious inefficiencies.

 SWC self-reporting is structurally compromised — non-uniform, unverified, and ungoverned.

Measurement is Management: The Water Balance Diagram



- "What gets measured, gets managed."
- A periodic Water Balance Study is the primary audit tool for identifying wastewater reuse opportunities and pushing past basic regulatory compliance.
- Requires daily metering of:
 - Raw water & Clarified water
 - Cooling tower makeup
 - Ash handling aux water & Fire water
 - DM makeup

What Water Audit Covers

Source-Wise Withdrawal

River, groundwater & STP —
disaggregated

Daily Intake Records

Continuous logging at
calibrated meter points

Meter Inventory

Calibration status, gaps &
accuracy audit

Overall Water Balance

Reconcile inputs/outputs;
identify losses

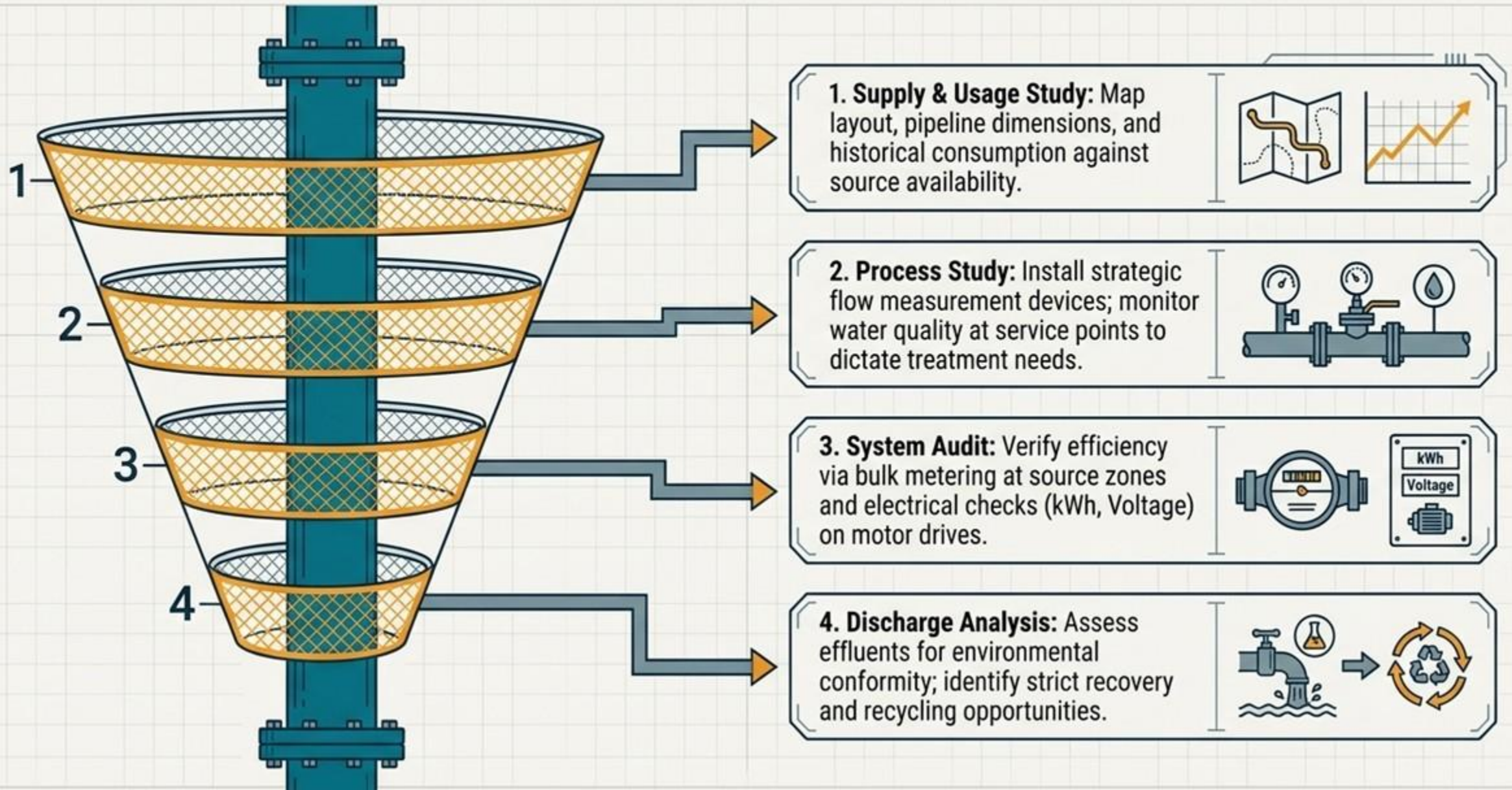
Cooling Tower Performance

COC, blowdown, drift & evaporation rates

Boiler, DM & Ash Handling

Condensate return, DM recovery, ash-water ratio

The Diagnostic Foundation of a System Audit



The Target: 20% Better Water Use Efficiency by 2027

NATIONAL WATER POLICY

20%

improvement in Water Use
Efficiency by 2027, sector-wide

Baseline year: FY 2024-25

- 1 Institutionalize an annual, independently-verified Water Audit at every TPP
- 2 Translate audit findings into an action plan for for water conservation & management
- 3 Move stations from periodic measurement to a continuous, consistent institutionalised periodic activity, involving external auditors and assurance agencies
- 4 Give CEA unit wide visibility
- 5 Provide early-warning on water-stress risk (source, season, El Niño-linked deficit)
- 6 Standardize to CEA SoP dataset so reporting to CEA, CPCB/SPCB and CGWA is consistent

WA Program: Scope & Applicability

WHO IS COVERED

- All coal, lignite and gas-based Thermal Power Generating Companies
- Central Sector (NTPC & other CPSUs), State GENCOs, and Private/IPP generators
- Generating units of 25 MW capacity and above, connected to the grid

WHAT IS COVERED — THE FULL WATER CYCLE

Raw water intake (surface / ground / municipal / sea) → internal transfer (cooling, DM plant, ash handling, fire-fighting, potable, colony, dust suppression) → recycling & reuse loops → final discharge / blow-down.

WHAT THIS FRAMEWORK DOES NOT DO

It does not supersede any existing obligation — it standardizes how compliance at TPPS is met and reported for the following -

- ✓ CPCB / SPCB consent conditions
- ✓ CGWA groundwater extraction permits
- ✓ MoEF&CC Environmental Clearance conditions on SWC
- ✓ Zero Liquid Discharge (ZLD) norms already applicable

The Annual Water Audit: The Core Principles

credible, comparable annual Water Audit at every eligible TPP.

The audit will establish **evidence, identifies losses and drives annual corrective action.**

Annual audit cycle

Every year: prepare → audit → submit → act → review progress.

Common baseline

Certify SWC, water balance, source mix, reuse share, metering status and key losses.

Action-oriented outcome

Each audit must result in a **time-bound water-conservation and compliance action plan.**

Annual cycle

FY-end data closure → Independent audit → CEA submission → Plant action plan → Quarterly review →
Next-year verification
| REPEAT |

The Six-Stage Water Audit Protocol

1

Desk Review

Design water balance, consents, permits, EC conditions, prior audits/DPR

2

Site Assessment

Walkdown of systems; metering inventory vs. mandatory points; TSW/STP mapping within 50 km

3

Water Balance Reconstruction

Full station balance: intake, transfer, recycle/reuse, discharge; losses quantified

4

Data Collection

Daily SWC & recycled share, own baseline, and work for 20%-by-2027 trajectory

5

Report identify Gap

Avoidable losses, metering gaps, status - manual Vs. digitized

6

Report Recommendations

Prioritized measures with indicative cost & expected saving — input for future pathways/digitalization

A Common Delivery Plan

Indicative plant category	Suggested audit scope	Indicative Fees	Typical complexity drivers
Up to 500 MW	Annual audit + standard report	To be determined locally through Fair & transparent procurement;	Single unit/source; limited nodes
>500–1,500 MW	Annual audit + detailed balance	may vary on a case-to-case basis, travel/stay, specialized testing and	Multiple units; ash/FGD/TSW interfaces
>1,500 MW / complex station	Annual audit + multi-unit review	DPR/project implementation.	Multi-source, large ash systems, ZLD/FGD, complex reuse

Standard Water Audit Report

- | | | |
|---|--------------------------------------|---|
| 1 | Plant Profile | Plant profile, permits/consents, design balance, past reports and source details. |
| 2 | Site audit & meter review | Walkdown, meter inventory, spot checks, data-quality assessment and STP/TSW mapping. |
| 3 | Reconciled water Data | Quantify intake, transfer, reuse, discharge and unaccounted-for water by major process node. Data Collection and reconciliation for various streams |
| 4 | Benchmark & findings | Assess SWC and reuse performance for each stream; identify compliance risks and conservation opportunities. |
| 5 | Certified action plan | Baseline and plant-wise corrective-action plan within target dates, Data templates · minimum evidence · qa/qc · certification · action-tracking |

Non-Compliance

AT THE GENERATING STATION

Head of the Generating Company

Accords priority; ensures budget & manpower for audit, DPR & implementation

Nodal Water Officer

Owens the Digital Water Ledger; liaises with the audit agency & CEA

Water Audit Committee (chaired by Plant Head)

Reviews the DPR & quarterly reports; oversees the Action Plan

FOR COMPLIANCE GAPS

Trigger	Consequence
Audit not conducted / submitted on time	Flagged as CEA Non compliance record and may affect SWC authenticity
SWC exceeds notified MoEF&CC limit	Show-cause; Environmental Compensation
Discharge exceeds consent standards	Compensation; possible closure direction
Persistent non-compliance	CTO non-renewal — existential risk

This Year's Plan : Dates

Report	Responsibility	Due / Submitted to CEA
Release the standard SOP , For TPPs and auditors: audit scope, methodology, templates, QA/QC, certification and corrective-action requirements. To be released by CEA	Immediate	
Self-Certified Water Balance & WUE, Nodal Persons & Action Plan	Immediate	By 15 October
Annual Water Audit Report (through Listed Agency)	Annually	By 30 June 2027
Technical Baseline Dossier	With each audit	First issue + each update
Water Neutrality / 3R Action Plan & closure status	Annually	With the Water Audit Report
DPR for Water Technology Management Project	Every 3 years	reviewed 3-yearly
Longterm MRV portal onboarding	Within 3 years	

All reports go to CEA — Civil Design Division.

Until the central digital portal is notified, submit by e-mail to cecd-cea@gov.in

CEA Support to Water Audit Ecosystem

Publish common audit Standards

Provide SOP, templates, MRV framework, water-balance workbook, audit checklist, corrective-action format and reviewer guidance for TPPs to follow and emulate.

Capacity Building of TPPs

Run TPP nodal-officer briefings, FAQs and annual learning reviews from time to time. Can undertake the WA as deposit works.

Define Appreciation

CEA will set criteria for appreciation of plants, nodal personnel, auditors, technology providers

List of reputed entities

CEA on the request of the TPP's can plan to list Water Auditors, MRV portals for the TPP's



NTPC Dadri (UP)

Implemented rigorous CT optimization and ash water recycling.

Result: 30% reduction in specific water consumption.



Tata Power Mundra (Gujarat)

RO desalination integration and massive STP reuse.

Result: 95% wastewater recovery, achieving absolute ZLD.



JSW Toranagallu (Karnataka)

Deployed dry ash handling and advanced STP integration.

Result: 40% reduction in freshwater draw.

Result of Successful Water Audit



Adani Power, Mundra (4,620 MW)

ETP, Secondary RO Plant, Sewage Treatment Plant, Coal Runoff Treatment Plant.

- Water saved: 15.68 lakh KL/annum
- Financial savings: ₹31.36 lakh/annum



Essar Power, Hazira (515 MW)

COC increased 3.68→5 (Cu-Ni tubes), blowdown reuse, PSF backwash recovery, swale filtration, thickener recycle.

- Water saved: 15.01 lakh KL/annum
- Financial savings: ₹225 lakh/annum



Jindal Power, Tamnar (1,000 MW)

• Equalization/settling ponds for effluent, ash water recycling from dyke, STP (400 KLD).

- Water saved: 9.65 lakh KL/annum
- Financial savings: ₹93,250/annum



NTPC Vindhyachal (3,260 MW)

• Comprehensive water audit (Apr–Jul 2010): ash water recirculation (+1,000 m³/hr), leakage plugging, CT overflow prevention, centralised ETP (63,933 m³/day).

- Potential annual savings: ₹28 crore

Direct Annual Recurring Savings

For 2X500 MW TPP 20% WUE SWC 3.5 to 2.8 saves Base case: 5.212 million m³/year. This is avoided withdrawal

Freshwater purchase / allocation / supply	₹1.56 crore	₹30/m ³
Pumping and water-treatment electricity	₹0.20 crore	0.65 kWh/m ³ at ₹6/kWh
Water-treatment chemicals	₹0.42 crore	₹8/m ³
ETP and ash-water system variable O&M	₹0.36 crore	₹7/m ³
Sludge, disposal, testing and monitoring	₹0.16 crore	₹3/m ³
Maintenance, consumables and operating benefit	₹0.37 crore	₹7/m ³
TOTAL DIRECT SAVING	₹2.87 crore/year	₹55/m ³ composite avoided cost

ASSOCIATED INDIRECT SAVINGS : Water allocation, cess, abstraction and supply charges, Raw-water intake operation and maintenance, Power used for long-distance conveyance and pumping, Clarification, filtration, DM/RO treatment and chemical consumption, Cooling-tower blowdown and wastewater treatment, Ash-water system losses and ash-pond return-water pumping, Sludge handling, laboratory analysis and environmental-monitoring costs, Emergency tanker/alternate-source cost during water shortage, Cost of operational disruption caused by water constraints, avoided generation loss.

20% WUE : Capital Investments if Required : No ZLD

Technology / activity	Scope for 2X500 MW TPP	Indicative CAPEX
Water-metering and digital water-audit platform	Source meters, use-point meters, effluent meters, data loggers, dashboard, reporting, calibration baseline	₹1.50 crore
Cooling-tower optimisation	Automated conductivity/blowdown control, online analyser, dosing automation, side-stream filtration, valves, instrumentation, distribution improvements	₹3.00 crore
Cooling-water chemistry upgrade	Improved inhibitor/biocide control, online chemical dosing, monitoring instruments, trial and commissioning	₹0.75 crore
DM/RO and condensate-system recovery	RO recovery upgrades, reject recovery/reuse, backwash optimisation, regeneration-water minimisation, piping	₹1.75 crore
Ash-water recirculation and recovery	Return-water system strengthening, clarifier/thickener/hydrocyclone, recirculation pumps, slurry-control improvements, pipeline rectification	₹3.50 crore
ETP tertiary treatment and reuse system	Filtration, UF/RO where needed, treated-effluent storage and reuse pumping/pipeline network	₹2.50 crore
Leakage reduction and hydraulic improvements	Pipeline repair, valves, tank overflow controls, automatic level controls, pump efficiency corrections	₹0.75 crore
Engineering, civil work, installation and commissioning	Foundations, tanks, cable works, erection, testing, commissioning and training	₹0.75 crore
Contingency	Approximately 10% of direct cost	₹0.50 crore
Total		₹15.00 crore

Benefits of WA: The Effluent Reuse Cascade

Strategic Rule

Treat effluent based on chemical profile, not by dumping everything into the Central Monitoring Basin (CMB). **Never use raw water** for low-grade physical processes.

Cascade Matrix		Destinations				
		Ash Slurry	Coal Dust Suppression	Fire Water	Clarifier Inlet	Horticulture / Greenbelt
Sources	Cooling Tower Blowdown	✓	✓	✓		
	DM Plant & CPU Regen Waste	✓				
	Filter Backwash				✓	
	STP Treated Sewage	✓				✓

The Plant-Wide Operational Playbook

REDUCE (Immediate Ops)

Push COC limits via aggressive ORP/LSI monitoring



Implement Hot-End blowdown

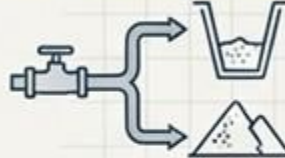


Optimize bottom ash flushing ratios (1:5)

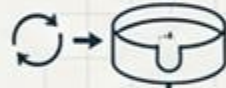


REUSE (The Cascade)

Route CT blowdown to ash/coal



Recirculate filter backwash to clarifiers



Divert township STP to greenbelts



RECYCLE (High-Capex)

Deploy RO for CMB effluent (70% recovery)



Transition fly ash to HCSD



Implement localized settling pits to isolate drains



Management Integration: Capitalize on Real-Time SCADA metering at all critical nodes for daily O&M review.



Thank You

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