Preliminary Energy audit study for Vita, Karad & Ichalkaranji

August 2024

CWAS CENTER FOR WATER AND SANITATION
CRDF CEPT RESEARCH AND DEVELOPMENT FOUNDATION
CEPT UNIVERSITY

Moving towards Carbon neutral City

Implementing "Energy transition initiatives in WASH service delivery" with technical support from Center for Water and Sanitation (CWAS), CRDF, CEPT University in partnership with HSBC to support Vita, Karad and Ichalkaranji urban local bodies

Acknowledgement

Recent global climate change events highlight the urgent need to assess and modify energy consumption across various sectors to mitigate climate impacts. Developing countries face the brunt of these effects, with India ranking as the 7th most vulnerable country to climate hazards. In Maharashtra, effective water supply and sanitation services are crucial for public health, environmental sustainability, social equity, economic development, and disaster resilience. Assessing emissions and mitigation potential in the water sanitation service chain, adopting renewable energy sources, and improving energy efficiency are key strategies to reduce climate impacts.

In this context, the Center for Water and Sanitation (CWAS), in partnership with HSBC, is supporting the cities of Vita, Ichalkaranji, and Karad in Maharashtra to move towards carbon neutrality. The CWAS team conducted a preliminary energy study of the water and sanitation value chain in these cities to enhance energy efficiency. This study assessed energy consumption, evaluated pump performance, calculated energy efficiency, and recommended pump replacements, including cost estimates and projected annual energy savings. Recommendations and a phased implementation plan were also provided.

We express our gratitude to the council officials of Vita, Ichalkaranji, and Karad for their excellent support. Discussions with other stakeholders, such as private contractors in the sanitation and water departments, have been invaluable in assessing the existing WASH services in these cities, paving the way for climate mitigation and adaptation initiatives.

Special thanks to the CWAS team members Omkar Kane, Aasim Mansuri, Jaladhi Vavaliya, and the city team members in Vita, Karad, and Ichalkaranji for their dedicated efforts in conducting the preliminary energy audit study. Your commitment and hard work are greatly appreciated.

Meera Mehta and Dinesh Mehta
Executive Directors, Centre for water and Sanitation
CRDF, CEPT University, Ahmedabad

Key assumptions considered to carry out the study

- **Assumptions Considered in Pump efficiency calculation**

- Pump flow values taken from **ULB-provided data** or **assumed** where measurements were unavailable
- **Motor efficiency assumed as 0.75 (75%)** as per standard engineering practice in formulas
- Standard water properties considered (density of water = **1000 kg/m³**)
- Pump operates **near the duty point** during measurement
- **Rated head and flow** used where real-time measurements were not available
- Pump head calculated/estimated using **pressure, pump curve or Total Dynamic Head** methods if not available in data
- Efficiency benchmark considered as **80%** for estimating potential energy savings (difference = inefficiency)
- Measurement readings assumed **representative of normal operation**
- Power factor insights cross-checked using **electricity bills**

Key assumptions considered to carry out the study

- **Assumptions Considered in Electricity cost and saving calculation**
- Electricity tariff considered: **₹7.53 per kWh**
- Annual energy cost estimates are based on **electricity bills from FY 2021–2022** received from respective Urban Local Bodies (ULBs)
- Calculations assume **current operational conditions remain unchanged**
- Savings are estimated considering **existing pump efficiency and operating hours**

- **Assumptions Considered in Life Cycle Cost Analysis**
- Electricity tariff: **₹7.53/kWh** (constant over analysis period)
- Analysis period: **10 years** for pump replacement
- Pumps efficiency will reduce **annually** **by** **2%**
- Annual savings estimated based on **daily operational hours**
- **O&M costs** included annually (based on current trend)
- Pump operation hours and water demand remain **unchanged**
- All savings are **direct monetary savings** from reduced electricity consumption
- Scrap/residual value of pumps at end of life **not considered**

India is the 3rd largest GHG emitter with energy sector as the largest contributor

India is 3rd largest GHG emitter among all the countries.

2,953 Mt CO_2e overall emissions

Energy sector the largest contributor

1. **Reduce the emissions intensity of its GDP to 45% below 2005 levels by 2030.**
2. **Achieve about 50% cumulative electric power installed capacity from non-fossil fuel-based energy resources by 2030.**
3. **Create an additional carbon sink of 2.5-3.0 billion tonne of carbon dioxide equivalent through additional forest and tree cover by 2030.**
4. **Propagate a healthy and sustainable way of living based on traditions and values of conservation and moderation, including through a mass movement for 'LiFE' – 'Lifestyle for Environment' as a key to combating climate change.**

Focusing on Carbon capture usage and storage technologies

Sector specific targets for all action and strategies

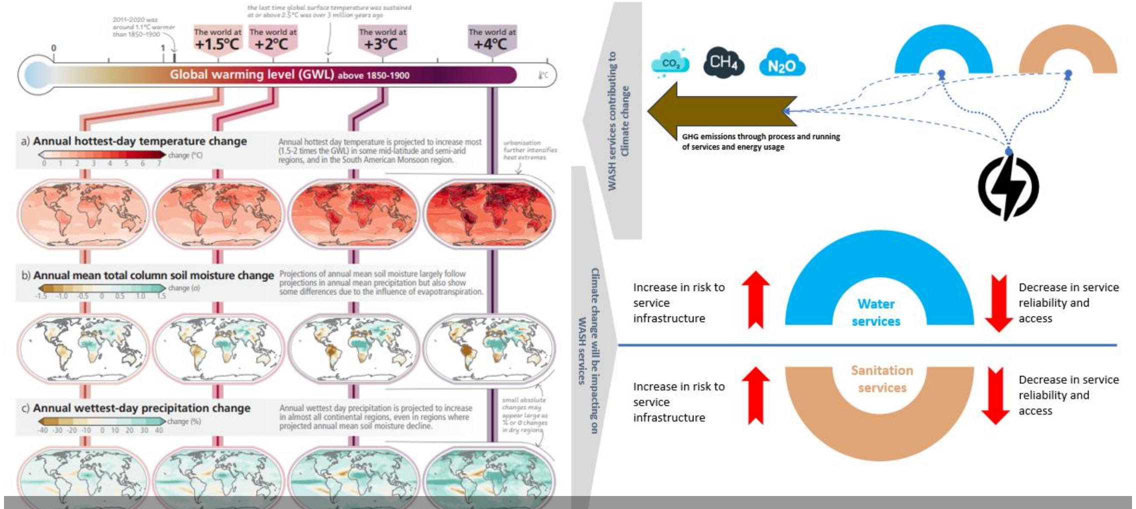
Focus on research and innovation towards clean fuel technologies

Focus on international cooperations and financial credit flows

Source: https://pib.gov.in/PressReleasePage.aspx?PRID=1876119

WASH services are under extreme threat due Climate change

- Global commitments focus on **energy transmission** as major agenda, with increasing the energy efficiency.
- **Reduce the emissions** intensity of its GDP to 45%
- Achieve about **50% cumulative electric power** installed capacity **from non-fossil fuel**-based energy resources by 2030.
- Propagate a healthy and sustainable way of living based on traditions and values of conservation, through a mass movement for **'LiFE' – 'Lifestyle for Environment'** as a **key to combating climate change.**



Impact of climate change on water and sanitation services: GHG emissions

- In order to optimize energy consumption a comprehensive energy assessment was conducted to evaluate energy losses in the water, sanitation, and hygiene (WASH) service chain in the city. This study systematically examined each component to identify energy inefficiencies and losses.

- By pinpointing these areas, the assessment aims to improve energy efficiency, reduce operational costs, and suggest measures for optimizing energy consumption. Implementing these initiatives will save costs and reduce the carbon footprint, enhancing environmental sustainability and financial efficiency.

Source: IPCC, 2023: Summary for Policymakers. In: Climate Change 2023: Synthesis Report. A Report of the Intergovernmental Panel on Climate Change. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, H. Lee and J. Romero (eds.)]. IPCC, Geneva, Switzerland, 36 pages. (in press) https://www.ipcc.ch/report/ar6/syr/downloads/report/IPCC_AR6_SYR_SPM.pdf ; https://news.un.org/en/story/2021/09/1098662
https://unfccc.int/sites/default/files/NDC/2022-08/India%20Updated%20First%20Nationally%20Determined%20Contrib.pdf

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Understanding Energy Audit and addressing Energy Loss

What is energy Audit?

- Energy Audit is a periodic examination of an energy system to make sure that energy is being used as capable as possible.
- Energy audit is a systematic study or survey to identify how energy is being used in a building or plant, and identify energy savings opportunity.
- With proper audit method and apparatus, an energy audit provides the energy executive with essential in sequence on how greatly, someplace and how energy is used surrounded by an organization

What is energy loss?

- Energy loss in any industrial process or plant is predictable; it’s a prearranged conclusion.
- However its economic and environmental impact is not to be living taken lightly, therefore explaining the increasing need for industrial energy efficiency.
- Place simply; the rank of energy efficiency a plant or development be capable of achieve is inversely proportionate to the energy loss that occur; the higher the loss, the lower the efficiency.

Release of green house gases resulting in global warming

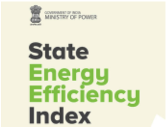
Source:ENERGY AUDIT FOR A WASTE WATER TREATMENT PROCESS by Ms. Gayatri R. Deshmukh1, Mr. Yeshu G. Deshmukh2, Prof. Ashvini B. Nagdwate3 (International Research Journal of Engineering and Technology (IRJET), Vol:4 issue 01 I 2017

Programs related to municipal energy efficiency in India

Cities spend an estimated 30-40% of their annual expenditure towards energy charges to address this

Various programs has been initiatives in India to make the municipal energy consumption efficient

- Energy Conservation Act 2001, section 18 for municipal water sector and street light
- National energy efficiency program under mission of NAPCC, 2008
- Development of energy efficient basic services guidelines for Indian cities. 2008
- Municipal energy efficiency program, 2016 – focus on pumps other municipal energy intensive appliance replacement and repair; star rating initiative
- Involvement of energy efficiency component in national mission like AMRUT & Jal Jeevan mission
- Program for municipal pumps audit and replacement initiative under MEEP by EESL for all state



अमृत 2.0
Atal Mission for Rejuvenation and Urban Transformation

ENERGY IS LIFE
BEE
CONSERVE IT

Initiatives taken to address the energy inefficiency

Maharashtra state energy conservation policy, 2017, and incorporation of energy efficiency component in state water supply scheme.

- Municipal service demand management
- Municipal energy efficiency program
- Municipal energy efficiency cell
- State level water supply schemes

Source: https://mahaurja.com/meda/data/energy_conservation/EC%20Policy%202017%20G.R-English.pdf ; https://beeindia.gov.in/sites/default/files/State-Efficiency-Index-2019%20%281%29.pdf; https://www.clearias.com/7-initiatives-to-promote-energy-efficiency-and-energy-conservation/; https://www.iea.org/reports/assessing-measures-of-energy-efficiency-performance-and-their-application-in-industry ; https://www.iea.org/policies/7457-municipal-energy-efficient-programme-meep

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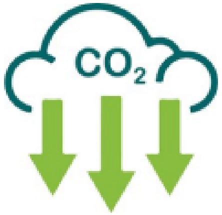
Objective of the study



- The objective of the study is to conduct a walk through energy audit, aiming to identify areas of energy wastage within the water supply and sanitation value chain.
- The focus is on suggesting effective measures to optimize energy consumption and pinpointing areas where energy-saving initiatives can be implemented. By achieving significant cost savings and reducing the carbon footprint, the overall goal is to enhance both environmental sustainability and financial efficiency.

“Energy savings directly linked to de-carbonisation, be it electricity or any carbon-emitting fuels”

Solution to achieve energy efficiency

Considering all methods to conduct energy audit, team has adopted walk through type method to understand the energy losses in the WASH service chain

METHODS TO CONDUCT ENERGY AUDIT

WALK-THROUGH ENERGY AUDITS

The Walk-Through Survey audit analyzes energy bills, visits the facility, and interviews key decision makers. It provides a report on energy usage, a benchmark, and recommendations for cost-effective energy efficiency improvements.

TARGET ENERGY AUDITS

The Energy Survey and Analysis audit enhances Level 1 by providing detailed energy breakdowns, measurements, peak demand analysis, savings evaluation, control strategy recommendations, and Level 3 analysis plans. Level 2 adds more energy and cost analysis.

DETAILED ENERGY AUDITS

The Capital-Intensive Modifications audit analyzes and develops identified capital projects from the Level 2 audit. It involves data collection, energy modeling, and detailed payback calculations, resulting in design drawings for the project.

Source: Presentation and documents from Energy Audit and Management course conducted by CSE

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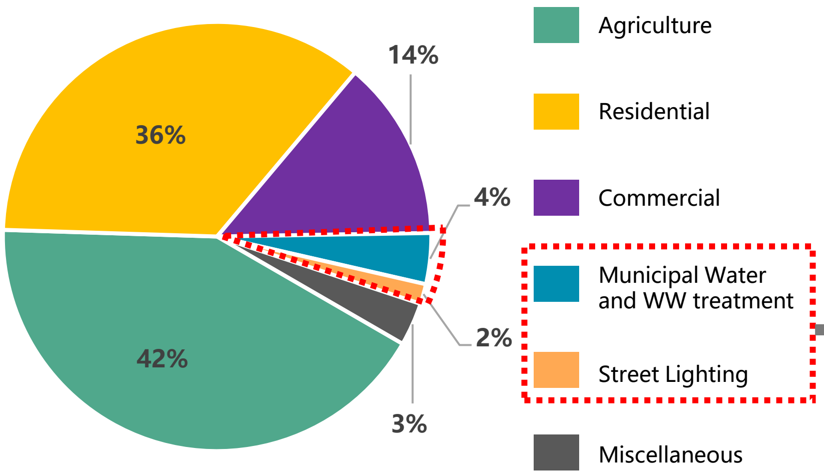
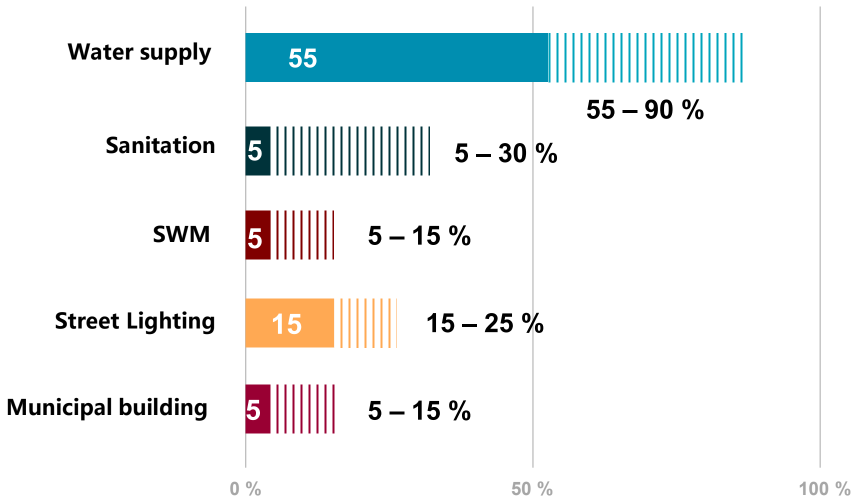
Small and Medium size towns can contribute to national and international commitments..

Distribution of electricity usage in Maharashtra



** Excluding traction and industrial electricity usage*

Distribution of Municipal electricity usage



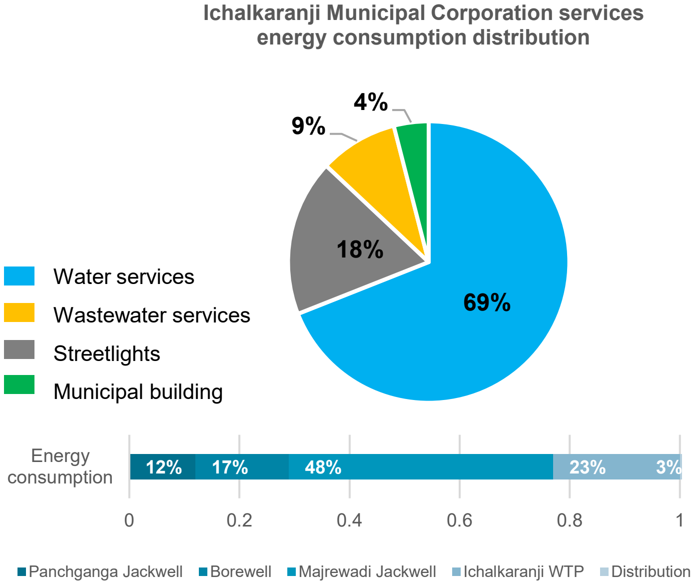
** Calculations carried out on a limited dataset of cities, numbers may vary on the larger dataset*

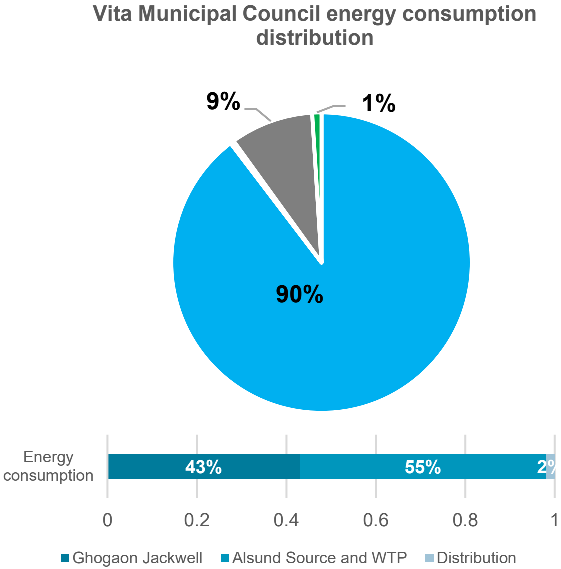
Minimum consumptions   Variable Consumption (Range variation)

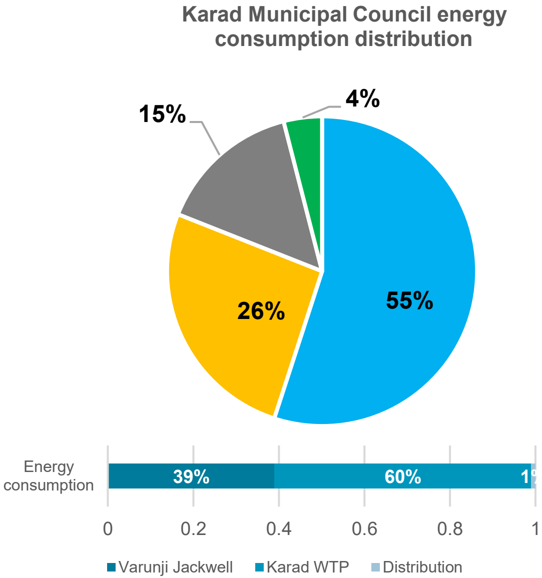
- **Municipal service accounts for 6 % of total electricity consumption, out of which WASH services contribute about 40 – 70 % of total energy consumption and about 50 to 70 % of municipal energy cost.**
- **For Ichalkaranji, Vita and Karad the energy cost for WASH service is INR 960, 650, and 220 lakhs per year respectively.**

- Source: Central Electricity Authority. (2023). All India Electricity Statistics - General Review. New Delhi: Ministry of Power, Government of India. Retrieved from https://cea.nic.in/wp-content/uploads/general/2023/GR_Final.pdf; Electricity department, Ichalkaranji Municipal Corporation – 2022 -2023; Electricity department, Vita Municipal council – 2022 – 2023; Electricity department, Karad Municipal Council – 2022 – 2023; * - approx. estimate based on common class factors derived based on electricity consumption across different class of cities in Maharashtra state.

Assessment of energy consumption for municipal service delivery done for Ichalkaranji, Vita and Karad







Water supply and sanitation systems are major users compared to energy usage by other municipal facilities

The reasons for having high energy consumption were identified such as

Distance of water sources	Poor electrical units (pumps) efficiency	higher NRW and water losses

Approx NRW is 25.5 % in nagar panchayats of Maharashtra.

Source : Ichalkaranji Municipal Corporation – 2022 -2023; Vita Municipal council – 2022 – 2023; Karad Municipal Council – 2022 – 2023

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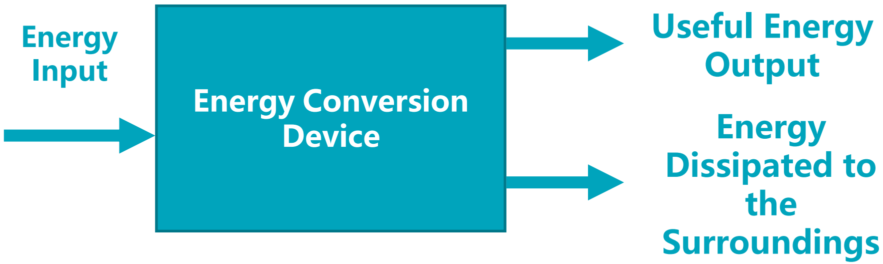
Achieving energy efficiency in municipal WASH services can assist in reducing the energy consumption and cost

Energy audit as a tool used by cities to assess the energy efficiency and performance of the energy equipment's.

Benefits of Energy Audit

- The **three top operating expenses** are **energy** (both electrical and thermal), labour and materials
- **Energy would emerge** as a top ranker for **cost reduction**
- Primary objective of **energy audit is to determine** ways **to reduce energy consumption** per unit of product output or to lower operating costs
- Energy audit provides a “bench-mark” for managing energy in the organization.
- **Environmental Impact -** Reduced carbon footprint and support for sustainability.
- **Improved Efficiency -** Identification and rectification of energy inefficiencies.

Calculation of Energy efficiency



$$\textbf{Energy Efficiency} = \frac{\text{Useful Energy Output}}{\text{Total Energy Input}}$$

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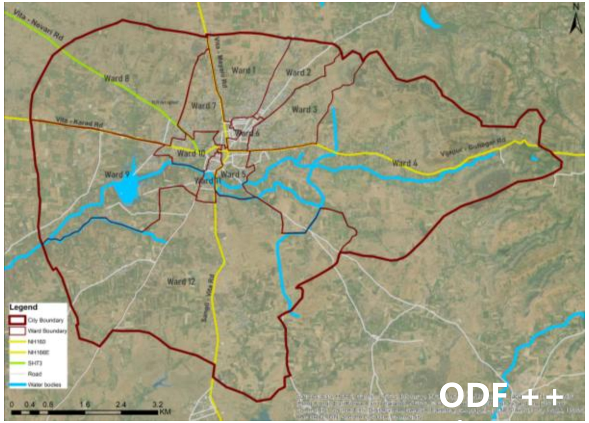
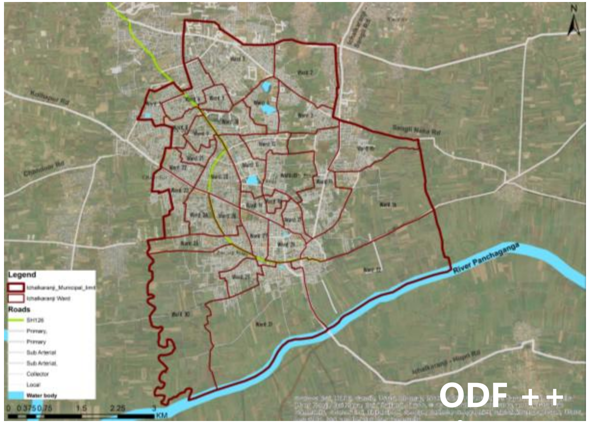
Demographics details for selected 3 pilot cities

Vita Municipal Council



Area	55.54 sq.km.	Population	57,000
Household	12,351	Commercial properties	1,492
Wards	12 Wards	Slum free city, 3 star GFC rating	

Ichalkaranji Municipal Corporation



Area	29.92 sq.km.	Population	3,68,916
Household	67,813	Commercial properties	15,900
Wards	31	Slum Household	4,047

Karad Municipal Council

Area	10.55 sq.km.	Population	89,725
Household	13,965	Commercial properties	5,505
Wards	15 Wards	Slum Household	275

Source: SLB PAS data: 2021

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Pumping asset mapping across the Water supply service chain in 3 cities

Water Supply service chain

	Ichalkaranji	Karad	Vita
Water Source	(2 sources)	(2 sources)	(2 sources)
	45 MLD; 1,730 HP; 18 and 4.5 Km away from WTP	20 MLD; 300 HP; 5 and 1 Km away from WTP	12 MLD; 315 HP; 45 Km away from City
Water Treatment	108 MLD; 16 hours operational/ day	33 MLD; 375 HP; 20 hours operational/ day	10.85 MLD; 300 HP; 17 hours operational/ day
Distribution / User end	11 Zones; 15 ESRs; 1,670 HP; 50 K connections	8 Zones; 9 ESR; Gravity based supply; 12,987 Connections	9 Zones; 15 ESR 3 GSR; 65 HP; 11 K Connections

Ichalkaranji

- Pumping of Raw water is done from 18 Km away to ensure better water quality.
- Major pumping assets are operational in lifting the water for treatment from the source.
- Due to slope variation distribution of treated water to the user end requires pumping from ESR, accounting for about 1670 HP of pumps.

Karad

- Due to the quality issues in raw water far water source is preferred by the Karad municipal council.
- The distribution network of Karad is completely dependent on the gravity system.
- Karad also provides water to habitation outside the city limit.

Vita

- Vita is dependent on a distance source for extracting raw water which is 45 Km away from the city and requires high energy costs for pumping.
- Slope provides benefit in reducing the pumping cost for the distribution of treated water to User end.
- As WTP is outside the city limit additional storages are created within the city limit for emergency supply.

Source: Ichalkaranji Water Supply department; Karad Water Supply department; Vita Water Supply department

Pumping asset mapping across the Sanitation value chain in 3 cities

Sanitation value chain

Ichalkaranji

User end

36 MLD Wastewater — 60 % sewer coverage

Pumping station

2 Zones — 1 pumping station — 270 HP

Sewage treatment plant

20 MLD

- Ichalkaranji has a mixed sanitation system with 60 % population dependent on a sewer system and 40 % on an onsite sanitation system.
- The slope assists in managing the sewer network through the gravity system for one sewer zone and the other sewer zone is dependent on pumping assets for transferring the sewage to a treatment facility with 270 HP capacity.

Karad

User end

10.5 MLD Wastewater — 100 % sewer coverage

Pumping station

5 zones — 6 pumping station — 192.5 HP

Sewage treatment plant

12.5 MLD Capacity — 100 % reuse for agriculture purpose

- Karad has a sewer network laid in 1983 and upgraded in year 2018.
- Karad city is divided into 5 zones with 6 pumping stations having pumping assets of functional 192.5 HP.
- The wastewater treatment is based on the MBBR technology with a capacity of 12.5 MLD and treated wastewater is used for agricultural purpose

Vita

User end

100 % onsite sanitation

Septic tanks

Effluent / Greywater

Faecal sludge treatment plant

10 KLD Capacity — 3 HP

- Entire population of Vita is dependent on the onsite sanitation system, with effluent from the containment system is channelised into drains.
- Faecal sludge is treated at the nature-based treatment facility with a capacity of 10 KLD.
- The treated sludge and wastewater is reused for watering the plants in urban forest, trees in city limit, washing road and washing municipal vehicles

Source: Ichalkaranji Drainage department; Karad Drainage department; Vita health and Sanitation department

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7 **Methodology & energy consumption in water and sanitation value chain in V-K-I**

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Overall process methodology adapted for estimating the energy efficiency

1 Understanding overall water and sanitation service chain

- Map the **entire water and sanitation system, including sources, treatment, and distribution**.
- **Collected data and conduct stakeholder interviews** to identify energy-intensive stages and operational challenges.

2 Analyzing the energy bills and analyzing the pump details

- Reviewed **previous energy bills and use sub-metering** to pinpoint **high energy users**.
- Inventory all pumps and assess their performance against specifications to identify inefficiencies..

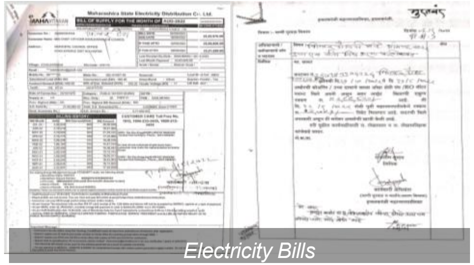
3 Identification of the low efficiency equipment

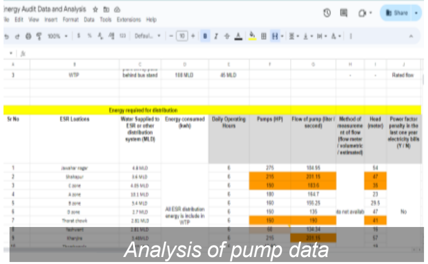
- **Compared equipment performance** with industry standards and **conduct physical inspections to identify inefficiencies**.
- Highlighted **underperforming equipments /pumps**

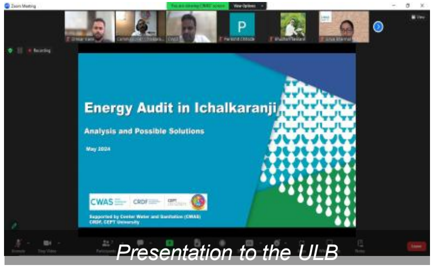
4 Recommendation and suggestions

- Proposal containing **equipment/pumps upgrades**, **operational changes**, and **enhanced maintenance practices** to improve efficiency.
- **Suggested integrating renewable energy sources** and **establish monitoring systems** for continuous improvement.


Site Visit to WTP and STPs


Electricity Bills


Analysis of pump data



Presentation to the ULB

Energy audit showcase pumps replacement or regular maintenance can assist in reducing the cost and energy consumption across water supply and Sanitation value chain

Ichalkaranji	Karad	Vita
Water Supply service chain		
• Overall **monthly consumption** of electricity across the water supply chain is over **1000 MWh** and **costs around 82 lakhs.** • The pumps at both sources have an efficiency below 50 %, replacing them can reduce energy consumption, improve pumping efficiency, and lead to cost saving.	• Overall **monthly consumption** of electricity across the water supply chain is over **230 MWh** and **costs around 18 lakhs.** • The pumps at both source have an efficiency below 40 %, replacing them can reduce energy consumption, improve pumping efficiency, and lead to cost savings.	• Overall **monthly consumption** of electricity across the water supply chain is over **657 MWh** and **costs around 54 lakhs.** • The pumps at both source and ESRs have an efficiency below 45 %, replacing them can reduce energy consumption, improve pumping efficiency, and lead to cost saving.
Sanitation value chain		
• Sanitation value chain contributes **10 % of total municipal energy consumption.** • Overall **monthly consumption** of electricity across the Sanitation value chain is over **140 MWh** and **costs around 16 lakhs**. • Trained human resources required for pump operations	• Sanitation value chain contributes **26 % of total municipal energy consumption.** • Overall **monthly consumption** of electricity across the Sanitation value chain is over **105 MWh** and **costs around 13 lakhs**. • The pumps at pumping have an efficiency of 10 % replacement will lead to cost reduction.	• The population is dependent on an onsite sanitation system requiring almost zero electricity for treatment. • Only the energy is consumed in terms of fuel i.e., diesel consumption by desludging vehicles which is about 800 to 1000 liters/year. • The fuel can be reduced through regular vehicle maintenance and route optimization

** Energy cost estimates as per electricity bill of year 2021 – 2022; Source – Based on the electricity bills received from local governments for year 2021 - 2022*

Calculation of Energy efficiency and other parameters related to energy assessment

Formulas:

- Pump Efficiency = **(Head X Flow of Pump) * 100 / (102*Pump (HP)*0.75)**

  (Note: 102 is the unit finishing constant)

- Electricity Rate = As given in electricity bills

- Estimate energy savings per year (Rs) =

  (80 – Pump efficiency) %*Pump (HP)*0.75*Daily operating hours*Electricity rate*365

- Pay back period in months = **(Pump replacement cost*12) / Estimated energy savings per year**

Sample calculations for Vita water supply resource and treatment plant is given as below

Water supply source:

- Pump Efficiency = **(Head X Flow of Pump) * 100 / (102*Pump (HP)*0.75)**
  = (190 X 58) * 100 / (102*300*0.75)
  = **48%**
- Estimate energy savings per year (Rs)
  = **(80 – Pump efficiency) %*Pump (HP)*0.75*Daily operating hours*Electricity rate*365**
  = (80 – 48) % * 300* 0.75* 20* 7.53*365
  = **39,55,612**
- Payback period in months
  = **(Pump replacement cost*12) / Estimated energy savings per year**
  = (60,00,000*12) / 39,55,612
  = **18**

(Note: At water supply there are two pumps with less than 50% which need to be replaced to achieve energy efficiency)

Water treatment plant:

- Pump Efficiency = **(Head X Flow of Pump) * 100 / (102*Pump (HP)*0.75)**
  = (190 X 83) * 100 / (102*300*0.75)
  = **68%**

(Note: At water treatment plant both the pumps are having efficiency more than 50% hence no need for replacement)

SIMILARLY ALL OTHER CALCULATIONS CAN BE DONE USING FORMULAS GIVEN

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Vita - Summary and Recommendations…(1/2)

- In water supply system, only Ghogaon Source and WTP has flow meters, in other places flow is measured through volumetric method that has higher percentage of errors as compared with meter measurement.
- Summary of no of pumps for replacement, estimated cost, payback periods and estimated savings for only inefficient pumps.

Sr No	Name	Pumps (HP)	Efficiency (%)	Estimated energy saving per year (Rs)	Cost of Pump Replacement	Pay back Period in Months	Power Factor Penalty (Y/N)
1	**Ghogaon Source (Krishna River)**	300	**48**	39,55,612	60,00,00/-	18	Y
2	**Alsund Lake source**	15	**13**	2,06,134	80,000/-	5	Y
3	Yashwant Nagar Pump (Distribution station)	20	**50**	61,840	90,000/-	17	Y
4	Panchashil Nagar (Distribution station)	30	**14**	4,86,961	1,50,000/-	4	Y
		10	**55**	10,347	52,000/-	60	
5	Vivekanada Nagar (Distribution station)	5	**19**	31,526	39,000/-	15	Y
6	**Alsund WTP**	300	**69**	-	60,00,00/-		Y

Recommendation: *Detailed energy audit / PPP contracts for energy audit and replacement of pumps; establishment of regular O&M practice, establish SOP for regular monitoring of energy efficiency.*

Vita - Summary and Recommendations…(2/2)

Sr No	Name	Power Factor Penalty (Y/N)	Present P.F.	Extra Energy Charges due to low P.F. (Rs.)
1	**Ghogaon Source Jackwell (Stage 1)**	Y	0.826	4,89,109
2	**Alsund Filter house (Stage 2)**	Y	0.862	3,38,946
	Total Extra Energy Charges due to Low P.F.			**8,28,055**

Yearly Saving Calculations

Sr No	Name	Power Factor Penalty (Y/N)	Present P.F.	Monthly Saving in Energy Charges due to Good P.F. (Rs.)	Yearly Saving in Energy Charges due to Good P.F. (Rs.)
1	**Ghogaon Source Jackwell (Stage 1)**	Y	0.826	4,89,109	58,69,308
2	**Alsund Filter house (Stage 2)**	Y	0.862	3,38,946	40,67,352
	Total			**8,28,055**	**99,36,660**

- Total amount of Installation of APFC channels = **Rs.33,42,078/- (2 APFC Channels)**
- Total Yearly saving amount after installation of APFC Panels = **Rs.99,36,660/-**

PAYBACK PERIOD = 4 TO 5 MONTHS

Recommendation: *Installing new power factor correction capacitors can result in an annual saving of approximately 99 lakhs in energy bills for the Urban Local Body (ULB)*

Vita –Life Cycle cost analysis for of pumps

Life cycle cost for one pump: Example calculation

Panchshil nagar pump life cycle cost

- **Pump Efficiency Degradation**:
  Assume a **2% drop in efficiency per year** — this leads to **increased energy consumption** and **reduced savings** over time.
- **Increased O&M Costs**:
  Let's assume **O&M costs increase by 5% annually** due to aging equipment and frequent repairs.

- Cost of Pump replacement : ₹1,50,000/-
- Assume pump life span is 10 years
- Operation & Maintenance Cost (10 years): ₹ 1,25,779
- Total Energy Saving (10 years) = ₹ 4,86,961 / for one year also considering 2% drop every year = ₹44,53,920

- Final Life Cycle Cost for Panchashil Nagar Pump =
  - LCC=₹1,50,000+₹1,25,779−₹44,53,920=**−₹41,78,142**

The **negative LCC of ₹41.8 lakh** means that over a 10-year period, **after covering all costs**, the municipality will **still save ₹41.8 lakh**.

A **negative Life Cycle Cost (LCC)** indicates that the **total monetary savings (primarily from reduced energy consumption)** over the pump's lifetime **exceed the total expenses** (which include pump replacement cost + operation & maintenance cost).

Vita –Life Cycle cost analysis for all pumps

Sr. No	Pump Name	Base 10-Yr Energy Savings (Rs)	Revised Savings After Wear & Tear	Cost (Pump + O&M)	New LCC (Rs)
1	Ghogaon Source	3,95,56,120	3,50,00,000	11,00,000	**-3,39,00,000**
2	Alsund Lake Source	20,61,340	18,00,000	5,80,000	**-12,20,000**
3	Yashwant Nagar	6,18,400	5,50,000	5,90,000	**-40,000**
4	Panchashil Nagar (2 pumps)	49,73,080	50,00,000	20,00,000	**-30,00,000**
5	Vivekananda Nagar (2 pumps)	3,18,730	2,80,000	5,00,000	**+2,20,000**
6	Alsund WTP	— (already efficient @ 69%)	Not Applicable	—	—

- **Still highly cost-effective for large, inefficient pumps** like Ghogaon, Panchashil, and Alsund Lake — even with reduced performance over time.
- **Small pumps** (like in Vivekananda Nagar) may have **marginal or even negative returns** if wear and tear is significant and energy savings are low.

Karad - Summary and Recommendations..(1/4)

- The pumps at the Varunji Source (Koyana River) need immediate replacement, with a payback period of only 1 month.
- A SCADA system should be installed at the water treatment plant to regularly monitor and improve operational efficiency.
- The pumps at the STP pumping stations require replacement.
- Training sessions are needed on Standard Operating Procedures for the regular operation and maintenance of pumps.
- Below is a summary of inefficient pumps:

Sr No	Name	Pumps (HP)	Efficiency (%)	Estimated energy saving per year (Rs)	Cost of Pump Replacement (Rs)	Pay back Period in years
1	Koyana river (Bulk water Purchase)	300	24	62,10,398	60,00,000	1
2	Varunji (WTP – Exraction and Conveyance)	375	39	54,23,058	75,00,000	1.4
3	BaraDabre, Karad (Total 33 motors)	289	4	1,08,76,583	57,00,000	0.5
4	Pumping station 1 (25 HP)	75	13	24,77,485	35,00,000	1.4
5	Pumping station 1 (75 HP)	225	14	48,76,074	52,00,000	1.1
6	Pumping station 2 (5 HP)	15	7	3,59,562	12,00,000	3.3
7	Pumping station 2 (10 HP)	30	5	7,39,818	15,00,000	2
8	Pumping station 3 (40 HP)	120	10	4,32,881	42,00,000	9.7
9	Pumping station 3 (75 HP)	225	14	51,90,906	52,00,000	1
10	Pumping station 4 (7.5 HP)	22.5	12	5,34,574	15,00,000	2.8
11	Pumping station 4 (20 HP)	60	14	13,05,029	35,00,000	2.6
12	Pumping station 6 (15 HP)	45	10	6,47,772	27,00,000	4.2
13	Pumping station 6 (30 HP)	90	12	12,55,126	37,00,000	3

All calculations are performed using electricity unit rate of ₹ 7.53 per unit

Karad - Summary and Recommendations..(2/4)

Sr No	Name	Power Factor Penalty (Y/N)	Present P.F.	Extra Energy Charges due to low P.F. (Rs.)
1	**WTP, new sump house**	Y	0.966	33,102
2	**Varuni new jackwell**	Y	0.989	6,536
	Total Extra Energy Charges due to Low P.F.			**39,638**

Yearly Saving Calculations

Sr No	Name	Power Factor Penalty (Y/N)	Present P.F.	Monthly Saving in Energy Charges due to Good P.F. (Rs.)	Yearly Saving in Energy Charges due to Good P.F. (Rs.)
1	**WTP, new sump house**	Y	0.966	33,102	3,97,224
2	**Varuni new jackwell**	Y	0.989	6,536	78,432
	Total			**39,638**	**4,75,656**

- Total amount of Installation of APFC channels = **Rs.33,42,078/- (2 APFC Channels)**
  - Total Yearly saving amount after installation of APFC Panels = **Rs.4,75,656/-**

PAYBACK PERIOD = 7 MONTHS

Recommendation: *Installing new power factor correction capacitors can result in an annual saving of approximately ~5 lakhs in energy bills for the Urban Local Body (ULB)*

Karad - Priority – wise pump replacement plan to improves energy efficiency in Water Supply and Sanitation value chain (3/4)

Phase 1

Sr No	Locations	Pumps (HP)	Efficiency (%)	Estimated energy saving per year (Rs)	Cost of Pump Replacement (Rs)	Pay back Period in years	Pump from value chain
1	Koyana river (Bulk water Purchase)	300	24	62,10,398	60,00,000	1	Water Supply
2	Varunji (WTP – Extraction and Conveyance)	375	39	54,23,058	75,00,000	1.4	Water Supply
3	BaraDabre, Karad (Total 33 motors)	289	4	1,08,76,583	57,00,000	0.5	Sanitation
	Total			**2,25,10,039**	**1,92,00,000**		

Phase 2

Sr No	Locations	Pumps (HP)	Efficiency (%)	Estimated energy saving per year (Rs)	Cost of Pump Replacement (Rs)	Pay back Period in years	Pump from value chain
4	Pumping station 1 (25 HP)	75	13	24,77,485	35,00,000	1.4	Sanitation
5	Pumping station 1 (75 HP)	225	14	48,76,074	52,00,000	1.1	
6	Pumping station 2 (5 HP)	15	7	3,59,562	12,00,000	3.3	
7	Pumping station 2 (10 HP)	30	5	7,39,818	15,00,000	2	
8	Pumping station 3 (40 HP)	120	10	4,32,881	42,00,000	9.7	
	Total			**88,85,820**	**1,56,00,000**		

All calculations are performed using electricity unit rate of ₹ 7.53 per unit

Karad -Priority – wise pump replacement plan to improves energy efficiency in Water Supply and Sanitation value chain (4/4)

Phase 3

Sr No	Locations	Pumps (HP)	Efficiency (%)	Estimated energy saving per year (Rs)	Cost of Pump Replacement (Rs)	Pay back Period in years	Pump from value chain
9	Pumping station 3 (75 HP)	225	14	51,90,906	52,00,000	1.4	Sanitation
10	Pumping station 4 (7.5 HP)	22.5	12	5,34,574	15,00,000	1.1	
11	Pumping station 4 (20 HP)	60	14	13,05,029	35,00,000	3.3	
12	Pumping station 6 (15 HP)	45	10	6,47,772	27,00,000	2	
13	Pumping station 6 (30 HP)	90	12	12,55,126	37,00,000	9.7	
	Total			**89,33,407**	**1,66,00,000**		

- Pumps can be replaced in three phases. In the first phase, replacing **three pumps** out of which **two at water supply** sources and **1 at STP Karad** will result in annual savings of **Rs. 2.25 Cr**, with a replacement cost of **Rs. 1.92 Cr.**
- In the second phase, five pumps need to be replaced at five different pumping stations from Pumping station 1 to Pumping station 3 at an estimated cost of **Rs. 1.56 Cr, resulting in annual savings** of **Rs. 88.85 lakhs.**
- In the third phase, **five pumps** from Pumping Station 3 to Pumping Station 6 need to be replaced, resulting in annual savings of **Rs. 89.33 lakhs** against a **replacement cost of Rs. 1.66 crore.**

Karad - year-by-year LCC (10 years)

- Replacement cost (sum of 3 phases) = **₹5.14 Cr**
- Year-1 energy saving (sum of phases) = **₹4.0318 Cr**
- Year-1 O&M (assumed 5% of replacement cost) = 0.05 × 5,14,00,000 = **₹25,70,000 = 0.257 Cr**

Year	Annual energy saving (₹)	Annual O&M (₹)	Cumulative energy saving (₹)	Cumulative O&M (₹)	LCC = Repl + Cum O&M – Cum Savings (₹)
1	4,03,17,999	25,70,000	4,03,17,999	25,70,000	1,36,52,001
2	3,95,11,639	26,98,500	7,98,29,638	52,68,500	-2,31,61,138
3	3,87,21,406	28,33,425	11,85,51,044	81,01,925	-5,90,49,119
4	3,79,46,979	29,75,096	15,64,98,025	1,10,77,021	−9,40,21,005
5	3,71,88,039	31,23,851	19,36,86,064	1,42,00,872	−12,80,85,193
6	3,64,44,298	32,80,044	23,01,30,362	1,74,80,916	−16,14,57,446
7	3,57,15,412	34,44,046	26,58,45,774	2,09,24,962	−19,47,70,788
8	3,49,99,104	36,16,248	30,08,44,878	2,45,41,210	−22,74,93,668
9	3,42,94,122	37,96,060	33,51,38,999	2,83,37,270	−26,02,75,269
10	3,36,15,042	39,86,914	36,87,54,041	3,23,23,184	−28,50,37,745

- Simple payback: **1.27 years**

All calculations are performed using electricity unit rate of ₹ 7.53 per unit

Ichalkaranji - Summary and Recommendations (1/2)

- Pumps at both primary water sources for bulk purchase are operating inefficiently and require immediate replacement.
- Among the 11 water distribution stations, 4 of them have pumps that are inefficient. However, since there is no metering at these stations, energy efficiency is assessed using estimated flow data.
- In this study, we couldn't calculate the efficiency of the sewerage pumping station due to a lack of flow data.
- Training sessions are needed on Standard Operating Procedures for the daily operation and maintenance of pumps.
- Below is a summary of pumps operating at less than 50% energy efficiency.

Sr No	Locations	Pumps (HP)	Efficiency (%)	Estimated energy saving per year (Rs)	Cost of Pump Replacement	Pay back Period in years
1	Krishna River	1080	**39**	1,46,79,956	75,00,000/-	0.5
2	Panchganga River	400	**46**	39,53,457	60,00,000/-	1.5
3	Jawahar nagar	275	**47**	11,06,283	57,00,000/-	5.2
4	A zone	180	**28**	11,68,560	42,00,000/-	3.6
5	B zone	160	**37**	8,42,663	37,00,000/-	4.4
6	Yashwant	60	**47**	2,46,158	15,00,000/-	6

Recommendation: *A SCADA system should be installed at the Water Distribution Stations and Sewage Treatment Plant (STP) to regularly monitor and improve operational efficiency. This installation will enable the Urban Local Body (ULB) to monitor daily flow seamlessly and operate pumps more efficiently.*

Ichalkaranji - Priority – wise pump replacement plan to improves energy efficiency in Water Supply chain (2/2)

Phase 1

Sr No	Locations	Pumps (HP)	Efficiency (%)	Estimated energy saving per year (Rs)	Cost of Pump Replacement	Pay back Period in years
1	Krishna River	1080	**39**	1,46,79,956	75,00,000/-	0.5
2	Panchganga River	400	**46**	39,53,457	60,00,000/-	1.5
	Total			**1,86,33,413**	**1,35,00,000**	

Phase 2

Sr No	Locations	Pumps (HP)	Efficiency (%)	Estimated energy saving per year (Rs)	Cost of Pump Replacement	Pay back Period in years
3	Jawahar nagar	275	**47**	11,06,283	57,00,000/-	5.2
4	A zone	180	**28**	11,68,560	42,00,000/-	3.6
5	B zone	160	**37**	8,42,663	37,00,000/-	4.4
6	Yashwant	60	**47**	2,46,158	15,00,000/-	6
	Total			**33,63,664**	**1,51,00,000**	

- Pumps can be replaced in two phases. In the first phase, replacing two pumps at the sources will result in annual savings of **Rs. 1.86 Cr**, with a replacement cost of **Rs. 1.35 Cr.**
- In the second phase, four pumps need to be replaced at an estimated cost of **Rs. 1.51 Cr**, resulting in annual savings of **Rs. 33.63 lakhs.**

Ichalkaranji - year-by-year LCC (10 years)

- Replacement cost (sum of 2 phases) = **₹2.86 Cr**
- Year-1 energy saving (sum of phases) = **₹2.1963 Cr**
- Year-1 O&M (assumed 5% of replacement cost) = 0.05 × 2,86,00,000 = **₹14,30,000**

Year	Annual energy saving (₹)	Annual O&M (₹)	Cumulative energy saving (₹)	Cumulative O&M (₹)	LCC = Repl + Cum O&M – Cum Savings (₹)
1	2,19,63,000	14,30,000	2,19,63,000	14,30,000	**80,67,000**
2	2,15,23,740	15,01,500	4,34,86,740	29,31,500	**−1,19,55,240**
3	2,10,93,265	15,76,575	6,45,79,005	45,08,075	**−3,14,71,930**
4	2,06,71,400	16,55,404	8,52,50,405	61,63,479	**−5,04,87,926**
5	2,02,57,972	17,38,174	10,55,08,377	79,01,653	**−6,90,07,724**
6	1,98,52,813	18,25,082	12,53,61,190	97,26,735	**−8,60,05,945**
7	1,94,55,767	19,16,336	14,48,16,957	1,16,43,071	**−10,19,89,028**
8	1,90,66,652	20,12,153	16,38,83,609	1,36,55,224	**−11,79,32,615**
9	1,86,85,319	21,12,760	18,25,68,928	1,57,67,984	**−13,31,99,056**
10	1,83,11,602	22,18,399	20,08,80,530	1,79,86,383	**−15,42,95,111**

Summary: Savings in Vita, Karad and Ichalkaranji – 10 year Life Cycle Cost

Assumptions:

- Analysis horizon: **10 years**.
- Efficiency / saving degradation: **2%** reduction in energy savings per year.
- O&M: **Year-1 O&M = 5% of replacement cost,** then **+5% p.a.** geometric growth.

City	Investment (pump replacements + APFC) (Cr)	Year-1 energy saving (Cr/yr)	Simple payback (yrs)	10-yr cumulative energy savings (Cr) (2% p.a. decline)	10-yr cumulative O&M (Cr) (Yr-1 = 5% of inv; +5% p.a.)	10-yr LCC = (Inv + Cum O&M − Cum savings) (Cr)	Net 10-yr benefit in Cr
Karad	**5.14**	**4.03**	**1.30**	**36.88**	**3.23**	**−28.50**	**28.50**
Ichalkaranji	**2.86**	**2.20**	**1.30**	**20.09**	**1.80**	**−15.43**	**15.43**
Vita	**0.375 (replacement +APFC)**	**1.07**	**0.35**	**9.82**	**0.24**	**−9.21**	**9.21**

Negative LCC indicates:

- Lifetime cost of new pumps is lower than continuing with inefficient ones
- Investment pays back within the analysis period

LCC accounts for cumulative savings and O&M over the pump's life to capture true economic viability.

Across Vita, Karad, and Ichalkaranji:

- All pump replacements show negative LCC within 10 years → financially viable
- Cities save money
- Operational efficiency improves → fewer breakdowns & lower electricity bills

Thank you

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About us

The Center for Water and Sanitation (CWAS) is a part of CEPT Research and Development Foundation (CRDF) at CEPT University. CWAS undertakes action-research, implementation support, capacity building and advocacy in the field of urban water and sanitation. Acting as a thought catalyst and facilitator, CWAS works closely with all levels of governments - national, state and local to support them in delivering water and sanitation services in an efficient, effective and equitable manner.

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