



# **Landscape study of Methane Recovery in Sewage Treatment: Insights from Indian Cities**

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CRDF, CEPT University**

# Acknowledgements

In 2018, India's domestic wastewater sector contributed an estimated 63.76 Mt of CO<sub>2</sub>eq emissions, with methane reduction identified as a major mitigation opportunity (GHG Platform-India, 2018; UNEP & CCAC, 2021). Existing studies also indicate that actual emissions from wastewater often exceed theoretical estimates. India has committed to reducing the emission intensity of its GDP by 45% by 2030, making methane mitigation in the wastewater sector increasingly important.

This study aims to document and analyse these emerging practices, drawing on literature review, site visits, and discussions with ULB officials, STP operators, and private partners. Eleven cities with methane-recovery initiatives were identified, and detailed assessments of Jaipur, Ahmedabad, Surat, Nashik, and Pimpri Chinchwad are covered in this document. This study explores how Indian cities are capturing methane from wastewater systems and the factors that influence successful resource recovery.

The CWAS team gratefully acknowledges the support of the city officials, private operators, and support staff of all visited cities for facilitating the site visits and providing their valuable time, data, and documentation essential for this study.

This study was prepared by CWAS team - Dhvani Shah, Omkar Kane, and Karan Patil under the guidance of Jigisha Jaiswal, Aasim Mansuri and Dhruv Bhavsar.

# Executive Summary(1/2)

- Methane emissions from the wastewater sector represent a significant yet under-addressed climate challenge globally and in India. Globally, the sanitation sector is estimated to be the fourth-largest contributor to anthropogenic methane emissions. In India alone, domestic wastewater accounted for nearly 63.76 million tonnes of CO<sub>2</sub> equivalent (MtCO<sub>2</sub>eq) in emissions in 2018. With increasing urbanisation, expanding sewerage networks, and growing wastewater treatment capacity under programmes such as AMRUT 2.0 and Swachh Bharat Mission 2.0, methane emissions from the wastewater sector are expected to increase unless mitigation measures are integrated into treatment systems.
- Wastewater treatment plants (STPs) contribute to greenhouse gas emissions through both direct and indirect pathways. Direct emissions primarily occur from anaerobic sludge digestion, methane leakage from digesters and gas holders, and sludge handling and treatment processes. Sludge becomes a major source of methane generation within STPs. Indirect emissions arise from high electricity consumption associated with pumping, aeration, sludge treatment, and plant operations. Additional value-chain emissions are linked to sludge transport, chemical use, untreated discharges, and disposal practices. At the same time, STPs also provide one of the largest opportunities within the sanitation value chain to capture methane and convert it into a usable resource.
- This study reviewed methane recovery practices across selected Indian cities through literature review, field visits, and discussions with Urban Local Bodies (ULBs), plant operators, and private stakeholders. The assessment focused on understanding how different technological systems, operational practices, contractual arrangements, and monitoring mechanisms influence methane recovery performance and resource utilisation at STPs.
- The findings indicate that methane recovery performance varies significantly across cities and is strongly influenced by technology selection, operational efficiency, monitoring systems, and reuse pathways. Plants with modern infrastructure, gas-tight systems, efficient CHP engines, and stronger operational controls demonstrate comparatively better methane capture and electricity generation performance. In contrast, older systems with RCC gas holders, limited monitoring, outdated generators, and weak contracts with very limited focus on methane capture, experience higher methane leakage and lower energy conversion efficiency.

# Executive Summary(2/2)

- Across most Indian cities, captured biogas is primarily utilised for captive energy purposes, particularly for generating electricity and reusing it within the STP to offset internal energy demand and reduce operational expenditure. Jaipur remains one of the few examples where biogas is also supplied to a co-located bottling plant, demonstrating an advanced reuse pathway beyond captive consumption. National initiatives such as the SATAT (Sustainable Alternative Towards Affordable Transportation) scheme further create opportunities for integrating STP-derived biogas into compressed biogas (CBG) markets and clean energy transitions.
- The study also highlights the importance of strong backward and forward linkages for successful methane recovery systems. Backward linkages include stable sludge generation, reliable influent quality, efficient sludge pumping, and proper digestion systems that ensure sustained methane generation. Forward linkages involve viable reuse pathways such as captive electricity use, gas bottling, treated wastewater reuse, sludge reuse, and integration with energy markets. Weak linkage mechanisms often result in methane flaring, underutilisation of resources, and lower financial viability.
- Operational efficiency and skilled human resource play a critical role in achieving methane recovery potential. Efficient sludge management, stable influent quality, real-time monitoring systems such as SCADA, and technically skilled operators are essential for maintaining digester performance, managing shock loads, and reducing methane losses.
- Improving methane recovery efficiency is therefore important not only from a climate perspective, but also from an operational and financial perspective. Reducing methane leakages, improving sludge management, upgrading engines, optimising plant energy consumption, and strengthening monitoring systems can significantly lower O&M costs. At the same time, improving resource recovery pathways through electricity generation, gas utilisation, treated water reuse, sludge reuse, and carbon markets can create additional revenue opportunities and improve the long-term financial sustainability of STPs.
- The study concludes that future STPs should not be viewed only as wastewater treatment facilities, but as climate-responsive resource recovery systems. Improving methane recovery offers cities an opportunity to reduce emissions, lower operational costs, strengthen financial sustainability, and contribute to circular economy and clean energy goals.



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- Way forward



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## 1 Overview- Need and Approach of Study

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## 2 Documentation of Existing Methane Capture and Reuse Practice

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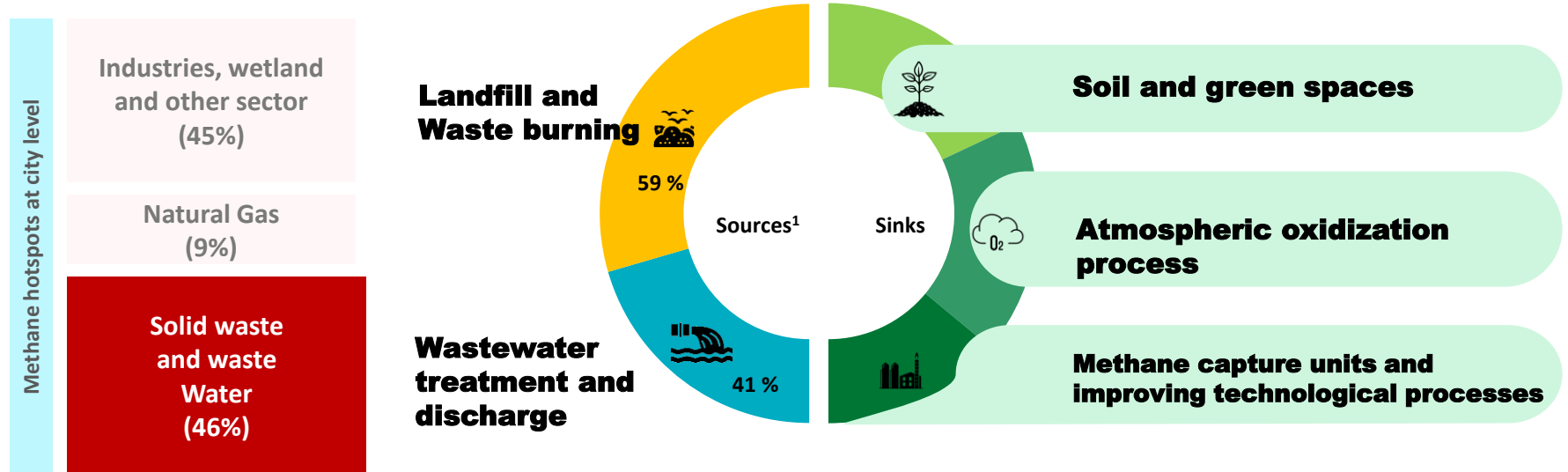
## 3 Key Findings and Learnings – *Affecting factors, Challenges, Opportunities*

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Way forward

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# Waste and sanitation, a key area in urban sector to tap the potent methane emissions



Sanitation and solid waste management are critical sectors where improved and safe management practices can generate multiple co-benefits, including enhanced public health outcomes and significant reductions in methane emissions. Poorly managed wastewater, sludge, and solid waste systems create anaerobic conditions that contribute substantially to methane generation, making these sectors important for climate mitigation efforts.

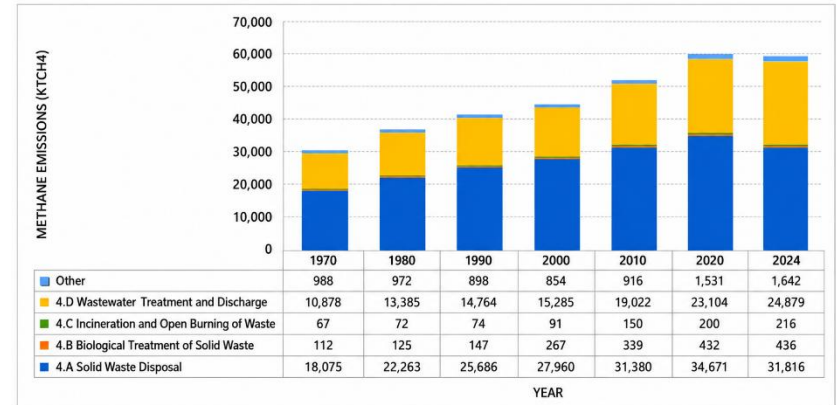
While many City Climate Action Plans acknowledge the relevance of sanitation and waste management, the focus of interventions and investments often remains concentrated on transport and energy sectors. As a result, the sanitation sector continues to remain an under-addressed yet high-impact opportunity within urban climate strategies. Integrating improved wastewater treatment, sludge management, faecal sludge and septage management, and waste processing systems into climate action planning can play a crucial role in achieving methane reduction targets while simultaneously strengthening environmental sustainability and urban resilience.

# Globally, waste water and solid waste are also the key emitters of potent methane gas

Methane (CH<sub>4</sub>) is the second most important greenhouse gas after carbon dioxide (CO<sub>2</sub>). It has a warming potential at least 80 times more powerful than CO<sub>2</sub>. Anthropogenically caused methane emissions predominantly stem from the following sectors: agriculture (40%), fossil fuels (35%), and waste including solid waste and wastewater (20%) (CCAC, 2025). Amongst this, methane emissions from waste are the fastest-growing source (ESCAP, 2025).

As fig 2 highlights, India emits over 4,800 kt of CH<sub>4</sub>, with significant contributions from wastewater and solid waste. China is the leading emitter, with nearly 6,985 kt CH<sub>4</sub>, mainly from wastewater and solid waste. Methane emissions from the former are almost 17 times higher than from the latter. As per the figure, treated and discharged wastewater emits more methane emissions in comparison with the solid waste sector.

Fig.1: Global methane emissions from the waste sector, 1970- 2024



Source: ESCAP, 2025, based on Emissions database for Global Atmospheric Research (EDGAR)

Fig.2: Country wise methane emissions from the waste sector

Ranking	Country	2024 Methane Emission from the Waste Sector (ktCH <sub>4</sub> )					Total
		4.A	4.B	4.C	4.D	4.E	
1	China	368.06	10.24	111.51	6,192.43	302.59	6,984.84
3	India	969.41	55.43		3,767.79	10.89	4,803.52
4	Russian Federation	2,109.04	13.37		1,035.34	26.73	3,184.47
2	Indonesia	611.60	22.20		1,298.46	10.89	1,943.15
5	Thailand	545.05	5.29	1.14	394.36	5.76	951.61
6	Pakistan	599.21	0.01		274.54	4.54	878.30
7	Türkiye	477.10	0.52	0.09	127.83	136.85	742.39
8	Republic of Korea	217.22	9.93	2.25	426.08	8.63	664.12
9	Viet Nam	384.81	0.08	2.49	227.37	2.38	617.13
10	Bangladesh	292.96	0.13		260.46	54.66	608.21

4.A Solid Waste Disposal;  
4.B Biological Treatment of Solid Waste;  
4.C Incineration and Open Burning of Waste;

4.D Wastewater Treatment and Discharge;  
4.E Other

Source: ESCAP, 2025

# International agendas and initiatives focus on the potent methane emissions



## Global Methane Initiative (GMI)

## UNFCCC Climate Conferences (COPs)

## Paris Agreement Context

## Climate and Clean Air Coalition

## Global Methane Pledge

## Oil and Gas Methane Partnership

## International Energy Agency (IEA)

- A voluntary international partnership launched in 2004.
- **Focus:** Reducing methane emissions while capturing it as a clean energy source.
- Works across sectors like landfills, coal mines, and oil & gas systems.
- Encourages technology sharing and capacity building.

- Annual climate summits under the United Nations Framework Convention on Climate Change (UNFCCC).
- Methane has become a growing priority in recent COPs:
- **COP26:** Launch of Global Methane Pledge.
  - **COP27:** Strengthened focus on implementation and monitoring.
  - **COP28:** Push for methane tracking, transparency, and sector-specific commitments.
  - **Role:** Provide a global platform for coordination, reporting, and policy alignment.

- Adopted at Paris Agreement.
- While not methane-specific, it drives countries to:
  - Include methane in Nationally Determined Contributions (NDCs)
- Methane reduction is key to meeting the 1.5°C climate target

- A global partnership hosted by UNEP.
- Targets short-lived climate pollutants (SLCPs) like methane.
- Works with governments and businesses to:
  - Develop policies
  - Support implementation
  - Promote best practices

- Launched at COP26 in 2021 by the United States and European Union.
- **Goal:** Reduce global methane emissions by at least 30% from 2020 levels by 2030.
- **Focus sectors:** energy (oil & gas), agriculture, and waste.
- Over 150 countries have joined.
- **Significance:** Methane is a short-lived but highly potent greenhouse gas, so cuts deliver quick climate benefits.

- Led by the United Nations Environment Programme (UNEP).
- OGMP 2.0 is the current framework.
- **Goal:** Improve measurement, reporting, and reduction of methane emissions in oil & gas operations.
- Companies commit to accurate data and transparency standards.

- The International Energy Agency tracks methane emissions globally.
- Publishes the **Global Methane Tracker**, highlighting:
  - Emission sources
  - Reduction opportunities
- Emphasizes that many methane reductions are low-cost or cost-saving.

# In India as well, the wastewater sector is one of the source of methane emissions contributing significantly to climate change

Sanitation is the **fourth-largest contributor to global methane emissions**<sup>2</sup>, currently contributes 7-10% of methane emissions globally, producing about 34 Mt methane emissions per year.<sup>3</sup> Methane emissions result from anaerobic fermentation of organic material in wastewater and are released from both residential and industrial sources when entirely untreated before being discharged, or when treated (inadequately) under anaerobic conditions.

In **India it accounts for nearly 10% of national methane emissions**<sup>4</sup>. Despite this, the wastewater sector remains significantly under-addressed in climate mitigation efforts. As shown in fig. 3, methane is one of the largest GHG share amongst the other gases in the waste sector. Moreover, domestic wastewater emissions are 45 percent of the waste emissions. If BAU continues, fig 4 identifies 3 times increase in emissions from the wastewater as the production of wastewater will also increase.

Methane generated in wastewater systems presents a major opportunity. If captured, it can serve as a renewable energy source for treatment facilities, reducing operational energy costs and greenhouse gas emissions.

**Fig. 3: GHG emissions across the waste sector components along with share of GHGs**

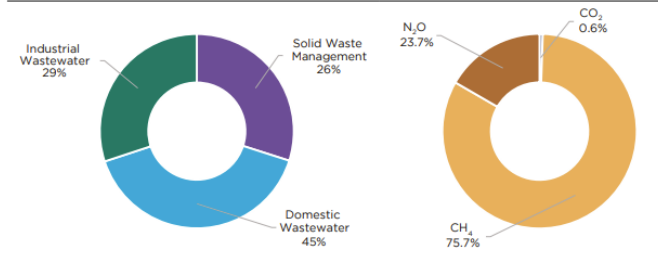
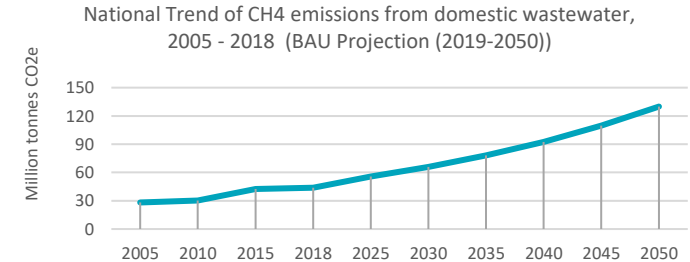


Figure 2.2: Subsector-wise share of GHG emissions in India's waste sector in 2020

Figure 2.3: Share of green house gases in India's waste sector emissions in 2020

Source: NITI Aayog, 2025

**Fig. 4: National Trend of CH4 emissions from domestic wastewater**



Source: Author calculations based on ICLEI base values

Source: <https://www.epa.gov/global-mitigation-non-co2-greenhouse-gases> extracted from <https://www.globalmethane.org/methane-emissions-data.aspx#about> 2. <https://climateandhealthalliance.org/wp-content/uploads/2023/08/MethaneReport-Waste-FINAL.pdf> ; 3. DeFabrizio et al., 2021: Curbing methane emissions – How five industries can counter a major climate threat. McKinsey & Company; 4. <https://globalmethane.org/methane-emissions-data.aspx> 3. United Nations Environment Programme (2021). Emissions Gap Report 2021: The Heat Is On – A World of Climate Promises Not Yet Delivered. Nairobi

# Methane emissions occur across various aspects of the sanitation value chain

Methane emissions occur across multiple stages of the sanitation value chain, with significant contributions arising from containment systems, treatment plants, and the discharge of untreated wastewater into the environment. Among these, sludge generated at sewage treatment plants (STPs) is one of the major sources of methane emissions due to the anaerobic decomposition of organic matter.

Emissions are further intensified by inadequate operation and maintenance of sanitation infrastructure, inefficient treatment processes, poor sludge handling practices, and the direct release of untreated or partially treated wastewater. Therefore, improving sludge management practices including efficient collection, treatment, stabilization, resource recovery, and safe disposal is critical for mitigating greenhouse gas emissions from STPs and enhancing the overall climate resilience of sanitation systems.

As per IPCC, there are three types of emissions from the systems:

- Direct emissions (scope 1): Emissions by sanitation value chain. Methane, Nitrous Oxide
- Indirect emissions (Scope 2): Emission through the fuel and generation of electricity, which is used in the water and wastewater service chain.
- Indirect emissions (Scope 3): Emissions by sanitation value chain. Methane, Nitrous Oxide

Fig.5: Methane emissions across sanitation value chain

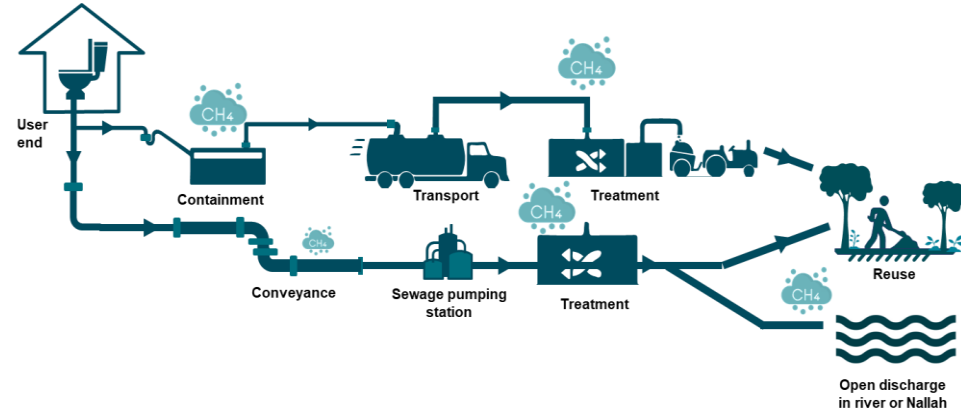
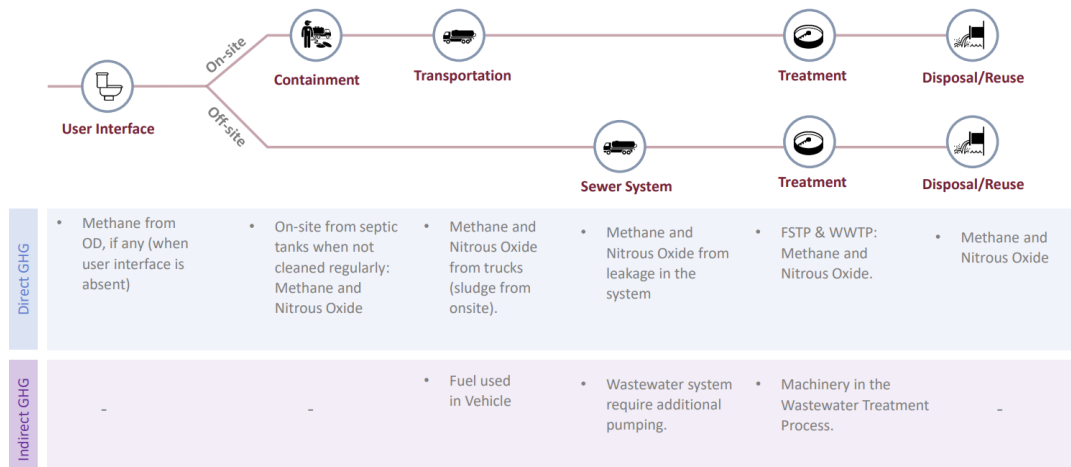


Fig.6: Types of emissions as per IPCC



# Direct and indirect emissions from sanitation value chain

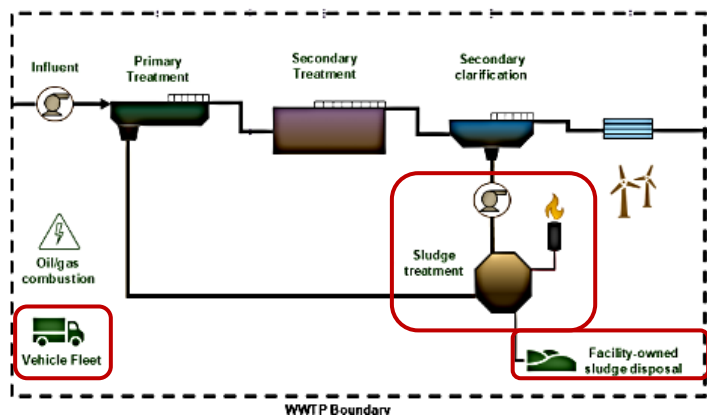
**Direct emissions** from wastewater and sanitation systems are greenhouse gases released directly during the collection, containment, transport, treatment, and disposal or reuse of wastewater and faecal sludge. The primary direct emissions are **methane (CH<sub>4</sub>)** and **nitrous oxide (N<sub>2</sub>O)**, generated under anaerobic and nitrogen-rich conditions. In on-site sanitation systems such as septic tanks and pits, methane is emitted when sludge accumulates and is not desludged regularly. During transportation, sludge-carrying vehicles may also contribute methane and nitrous oxide emissions. In sewer systems, direct emissions occur through leakages and anaerobic conditions within sewer networks. Wastewater treatment plants (WWTPs) and faecal sludge treatment plants (FSTPs) further emit methane and nitrous oxide during biological treatment processes, while disposal and reuse activities can also result in the release of these gases. In situations where toilets or user interfaces are absent, open defecation can additionally contribute methane emissions.



**Indirect emissions** from wastewater systems arise from the energy and fuel consumed to operate sanitation infrastructure rather than from the wastewater itself. These emissions are primarily associated with the combustion of fossil fuels and electricity use across the sanitation service chain. Fuel consumed by desludging and transport vehicles generates indirect carbon dioxide emissions, while sewer systems often require pumping stations that consume electricity for wastewater conveyance. Similarly, treatment facilities such as WWTPs and FSTPs rely on pumps, aerators, mixers, and other machinery, leading to additional emissions from energy use.

# Direct and Indirect - GHG emissions from the operation of STPs

## Direct emission

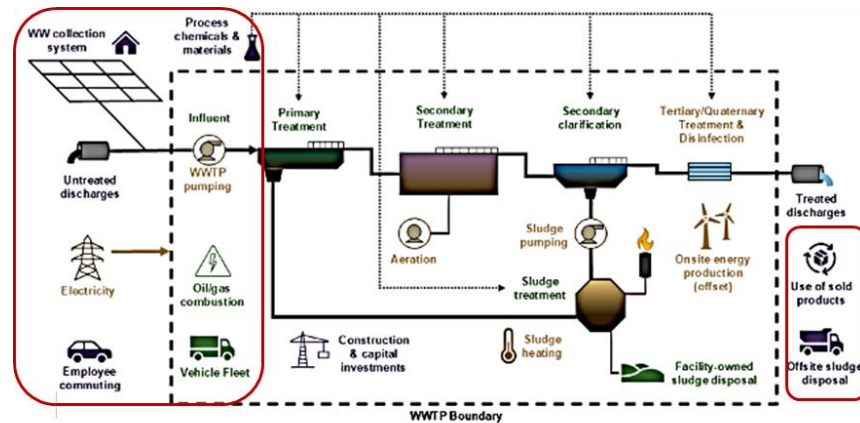


Methane is released during anaerobic decomposition of organic matter, particularly from sludge treatment units, digesters, and open handling systems.

### Direct emissions also occur through:

- Methane leakages from digesters and gas holders,
- Flaring inefficiencies,
- Sludge storage and disposal,
- Fuel combustion and vehicle operations within the plant boundary.

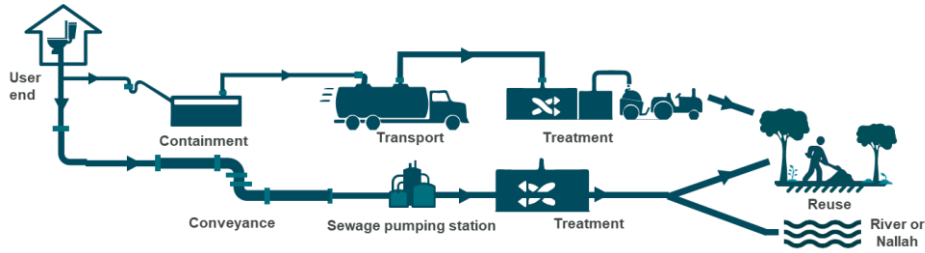
## Indirect emission



Wastewater treatment plants are energy-intensive systems, with major electricity consumption occurring through pumping, aeration, sludge handling, and treatment operations. These activities contribute to indirect emissions when electricity is sourced from fossil fuel-based grids.

Beyond plant operations, wastewater systems also generate emissions across the broader sanitation value chain. These include emissions associated with chemical use, construction materials and infrastructure, sludge transportation and disposal, treated wastewater discharge, employee commuting, external electricity generation, reuse or disposal pathways for sludge and treated products

# Efforts can be undertaken to mitigate methane emissions / resource recovery across sanitation service chain



## Containment & Conveyance

### Ensuring proper operation and maintenance of containment and conveyance infrastructure –

- 1. Regular desludging 3 – 5 year interval<sup>2</sup>** : - Desludging of containment facilities will reduce the BOD load and sludge accumulation on which the methane generating bacteria survives and decompose the organic matter and desludging will reduce the rate of methane emissions from septic tanks.
- 2. Lining of containment infrastructure<sup>3</sup>** : - Proper lining of containment infrastructure will reduce the contamination risk of groundwater and will reduce the methane emissions risk in ground water sources by reducing the wastewater infiltration into aquifers and reducing the moisture content.
- 3. Ensuring frequent cleaning of the sewer and drainage network<sup>4</sup>** : - Will reduce the blockage, chocking and silting which leads to methane emissions through decomposition.

Source:1. United Nations Environment Programme (2025). *Global Methane Status Report*. Paris. <https://www.unep.org/resources/report/global-methane-status-report-2025>; 2. [Greenhouse Gas Emissions from Blackwater Septic Systems](#); 3. [Greenhouse gas emissions from different containment system in Dhulikhel Municipality in Nepal](#); 4. [Reducing methane emissions from gravity sewer pipelines by ultrasonication](#); 5. [Investigating high methane emissions from urban areas detected by TROPOMI and their association with untreated wastewater](#); 6. [Wastewater-effluent discharge and incomplete denitrification drive riverine CO<sub>2</sub>, CH<sub>4</sub> and N<sub>2</sub>O emissions](#); 7. [Reduction of energy consumption and greenhouse gas emissions in wastewater treatment plant: A case study of utilizing anaerobic sludge digestion](#); 8. [Turning Human Waste into Renewable Energy: Scope and Options for India](#); 9. [Omission of emissions: the untapped potential of sanitation for climate mitigation in Nepal](#)

## Sludge and Wastewater treatment

- Installation of anaerobic digester with methane capture unit at the STPs<sup>7,8</sup> and small scale digester units at FSTPs<sup>9</sup>** : - Anaerobic digesters facilitate the controlled breakdown of organic matter present in wastewater and sludge under oxygen-free conditions. This process generates biogas, primarily methane, which can be captured and utilized as a renewable source of energy or fuel. Methane capture prevents uncontrolled release of greenhouse gases into the atmosphere while also supporting energy recovery at treatment facilities.
- Ensuring proper sludge treatment at the treatment facilities** : - Proper sludge treatment and stabilization reduce the organic and volatile solids content in sludge, thereby minimizing anaerobic decomposition during storage, handling, or disposal. This helps reduce methane emissions and improves environmental management of residual sludge.

## Discharge

- Reducing discharge of untreated usedwater in freshwater<sup>5, 6</sup>** : - Untreated used water contains high concentrations of biodegradable organic matter. When discharged into freshwater bodies, the organic matter settles and decomposes under oxygen-deficient (anaerobic) conditions, particularly in sediments and stagnant zones, leading to methane generation. Reducing the discharge of untreated used water and ensuring adequate treatment prior to disposal lowers the organic load entering water bodies, thereby minimizing anaerobic decomposition and associated methane emissions.
- Curbing the disposal of untreated sludge at the solid waste landfill** : - Untreated sludge contains significant amounts of biodegradable volatile solids and moisture, which undergo anaerobic decomposition when disposed of in landfills, producing methane emissions. Preventing the disposal of untreated sludge and promoting sludge stabilization or treatment prior to disposal reduces the biodegradable organic content responsible for methane formation. This helps in minimizing landfill-based methane emissions while improving overall waste management practices.

# Sewage Treatment Plants are the key intervention points for methane emission reduction in the sanitation value chain

Sewage Treatment Plants (STPs) can play a critical role in reducing methane emissions from the wastewater sector by serving as both points of methane generation and methane capture. A major source of these emissions within STPs is sludge, which accumulates during the treatment process and contains high concentrations of organic matter. When sludge is stored, thickened, or treated under anaerobic conditions without proper gas management, substantial quantities of methane can be released into the atmosphere. However, STPs equipped with anaerobic digesters and gas recovery systems can capture methane generated from sludge treatment, converting a potential greenhouse gas source into a valuable energy resource.

With increasing urbanization and expansion of sewerage infrastructure across India, STPs present a significant opportunity to contribute to national methane reduction goals. Captured biogas can be utilized for:

- electricity generation,
- upgraded into biomethane,
- Supply as cooking fuel
- reducing reliance on fossil fuels while enhancing the energy efficiency of treatment facilities
- It can reduce dependence on imported fuels, strengthening local energy systems

Integrating methane monitoring, sludge-to-energy technologies, and gas capture systems into existing and planned STPs can help cities achieve both sanitation and climate objectives. As urban local bodies develop climate action plans and methane reduction strategies, focusing on sludge management at STPs offers one of the most effective pathways for reducing methane emissions while promoting resource recovery and circular economy practices.



# Only 18 STPs in India practice methane capture and use it as a resource

According to the **Central Pollution Control Board (CPCB)** National Inventory of Sewage Treatment Plants (2021), India has 1,631 sewage treatment plants (STPs) with an installed treatment capacity of 31,841 MLD (million litres per day) against an estimated sewage generation of 72,368 MLD, indicating that less than half of the sewage generated could be treated. STPs were reported across more than 500 urban local bodies/cities and towns.

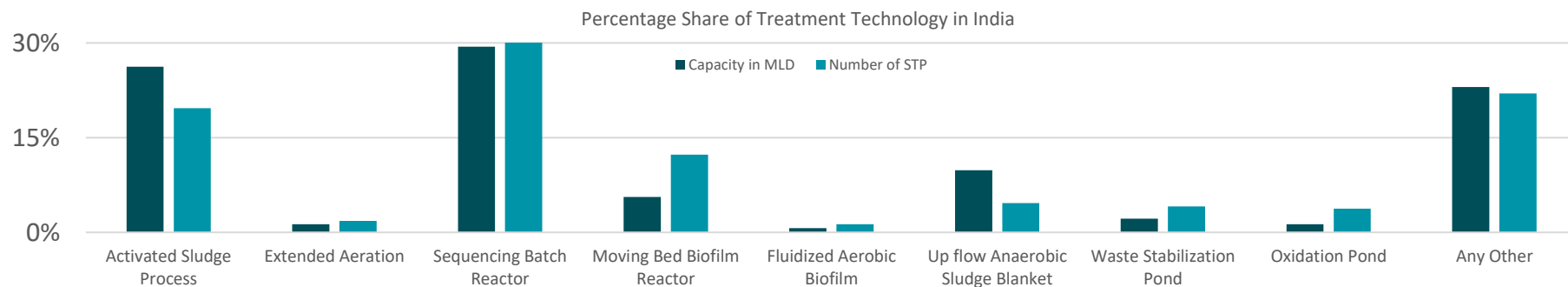
The inventory highlights that Sequential Batch Reactor (SBR) and Activated Sludge Process (ASP) are the predominant treatment technology in the country. Other technologies such as Moving Bed Biofilm Reactor (MBBR), Upflow Anaerobic Sludge Blanket (UASB), Oxidation Ponds, and Membrane Bioreactors (MBR) are also in use but constitute a smaller proportion of the overall capacity.

Only 18 STPs across India practice methane capture and utilize it as a resource. Cities including Jaipur, Surat, Ahmedabad, Delhi, Varanasi, Bengaluru, Pimpri

Chinchwad, Hyderabad, Nashik, Nagpur and Chennai- have STPs with energy recovery from wastewater. These efforts demonstrate growing interest in circular sanitation, where biogas, electricity and treated water are harnessed as usable resources while contributing to climate mitigation goals.

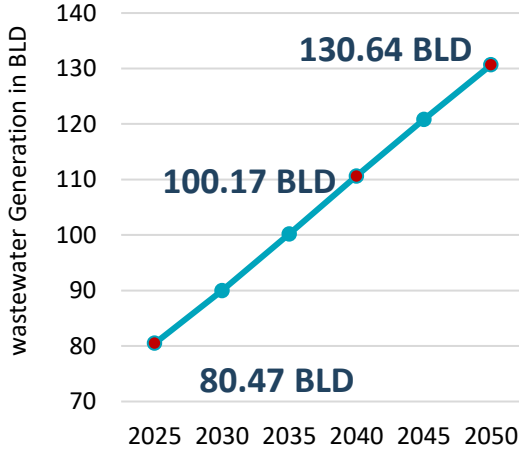
A 2021 CPCB-NIUA study found that of the 250+ STPs equipped with digesters, nearly 60% either flare the gas or leave the units underutilised due to a lack of mandates to recover and use biogas or CBG in new STPs.

This showcases, the potential of methane capture and utilization at STPs, as many STPs are equipped with digesters and need to move further towards converting the biogas into a resource



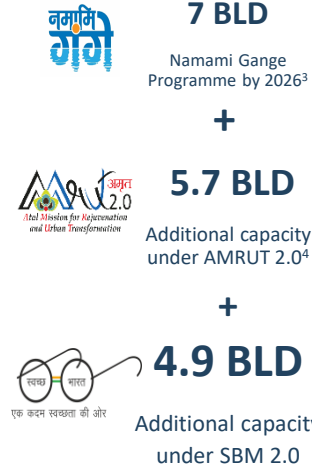
# At full scale, wastewater-based biogas could help reduce fossil fuel dependence of India and move towards NDC achievements

Estimated wastewater generation\* (BLD)<sup>1</sup>



Current operational treatment facility capacity  
– **36.18 BLD (40 % of total wastewater generated)<sup>2</sup>**

Planned capacities by year 2026



- India's wastewater generation is projected to rise sharply—from 80.47 BLD in 2025 to **130.64 BLD by 2050**
- At present, the country has an operational treatment capacity of only 31.4 BLD, which accounts for 40% of the total wastewater generated, indicating a significant treatment gap.
- To address this, major national programs such as Namami Gange, AMRUT 2.0, and SBM 2.0 are collectively planning to add over 17 BLD of new treatment capacity by 2026. So, total would be ~54BLD

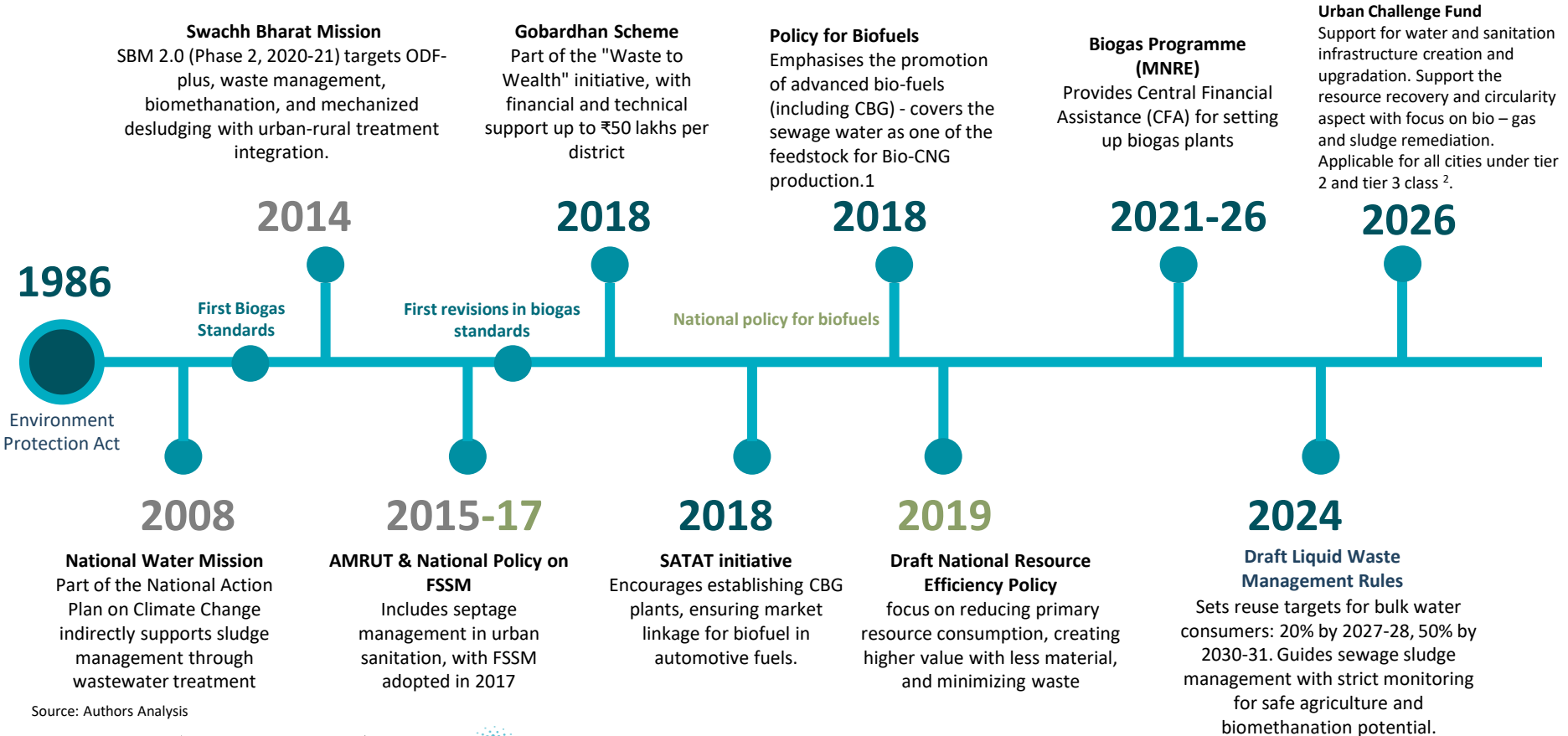
**Assuming by 2050, India's 100% WW will be treated at STPs that will have a biogas generation facility: So treatment capacity = 130.64 BLD**

*Considering average biogas yield of wastewater is 70 m<sup>3</sup>/ML (increased over time due to new technology adoption and interventions increasing yield)*

India can generate approximately: **Biogas 9 million cum/day, enough to either replace 5–6% of LPG demand, meet about 3% of natural gas needs through Bio-CNG, or generate electricity sufficient to power nearly 5 million households daily.**

Source: 1. NITI Aayog. (2023). *Revised strategy paper on reuse of treated Usedwater in peri-urban agriculture in India*. National Institution for Transforming India. [https://www.niti.gov.in/sites/default/files/2023-08/Revised\\_Strategy\\_Paper\\_on\\_Reuse\\_of\\_Treated\\_Usedwater\\_in\\_peri-urban\\_agriculture\\_in\\_India.pdf](https://www.niti.gov.in/sites/default/files/2023-08/Revised_Strategy_Paper_on_Reuse_of_Treated_Usedwater_in_peri-urban_agriculture_in_India.pdf); 2. <https://static.pib.gov.in/WriteReadData/specificdocs/documents/2025/nov/doc20251119698701.pdf> ; 3. <https://www.pib.gov.in/PressReleaseIframePage.aspx?PRID=1986271&reg=3&lang=2#:~:text=Under%20Namami%20Gange%20Programme%2C%20in.state%20and%20other%20other%20Agencies> .4. <https://www.pib.gov.in/PressReleaseIframePage.aspx?PRID=2041571&reg=3&lang=2> 5. <https://waponline.com/jwcc/article/doi/10.2166/wcc.2025.134/110374/Water-security-and-methane-reduction-in-Ganga>

# Indian ministries and missions also support methane mitigation from the sanitation sector directly and indirectly



Source: Authors Analysis

# India's CBG (Compressed Biogas) schemes, like SATAT helps offering financial support to private market and other schemes providing some financial support

## SATAT scheme

The Sustainable Alternative Towards Affordable Transportation (SATAT) scheme incentivizes oil companies to procure Compressed Biogas (CBG) from waste by offering a guaranteed purchase price (initially around ₹46/kg for 3 years) and the ability to market byproducts like manure, while providing entrepreneurs central financial assistance (CFA), assured offtake, and reduced import dependency for India

India's CBG (Compressed Biogas) schemes and CGD (City Gas Distribution) like **SATAT and Direct Pipeline Infrastructure (DPI)**, the **CBG-CGD synchronization schemes** respectively aim to integrate renewable biogas into city gas networks, offering financial support **for pipeline infrastructure (DPI) and mandating blending (5% by 2028-29) to reduce fossil fuel reliance and promote a circular economy by converting waste to energy**

In addition to the government's efforts, individual states also promote CBG initiatives. Punjab, Haryana, Uttar Pradesh and many other states have formed a state-level committee to monitor and implement the SATAT Scheme.

## Government scheme supporting initiatives



**The Ministry of New and Renewable Energy** notified Central Financial Assistance (CFA) of Rs.4 crore for 4,800 kg of CBG generated from 12,000 cubic metres of biogas per day, subject to a maximum of Rs.10 crore for each project.

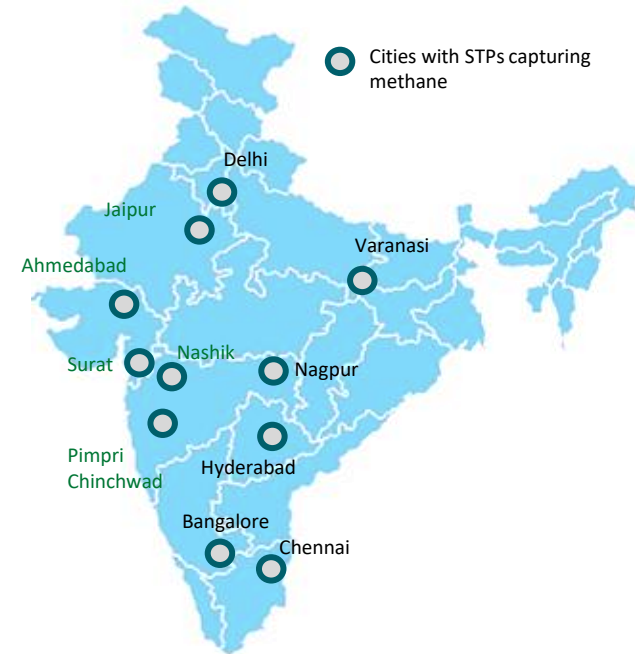
**The Reserve Bank of India (RBI)** has categorised CBG plants in the priority sector for lending to finance CBG projects. The State Bank of India (SBI) has launched a specific policy for financing CBG projects, and other banks are also adopting similar policies to finance CBG.

# With few cities taking up methane capture and utilization, it is important to conduct a study to understand scale approaches helpful in scale up of methane utilization at STPs

Currently, several practices are being implemented in the field where local governments have adopted approaches to capture methane from STPs and convert it into a resource. These initiatives have experienced both successes and challenges. The aim of the study is to document and analyze these cases, providing a comprehensive overview through a combination of literature review, site visits, and discussions with city officials, STP operators and private sector partners. This study will help to identify the factors contributing to the successes and failures of these plants.

**A landscape review helps compare diverse cases and develop insights that can guide cities toward more effective methane recovery strategies.** This study explores how Indian cities are capturing methane from wastewater systems and the factors that influence successful resource recovery.

**With more STPs adopting biogas systems, it is crucial to document early experiences so future investments can be more effective and sustainable.** This study explores how Indian cities are capturing methane from wastewater systems and the factors that influence successful resource recovery.



Source: National Inventory of Sewage Treatment Plants June 2020, <https://cpwb.nic.in/openpdf.php?id=UmVwb3J0RmlsZXMvMTIyOF8xNjE1MTk2MzlyX21ZGlhcGhv dG85NTY0LnBkZg==>, <https://www.wabag.com/wabag-blogs/waste-to-energy-achieving-self-sustenance-in-sewage-treatment-plant/>

# The main objective of the study is to understand the challenges and successful factors for methane recovery practices at STPs



1469 STPs are installed in India out of only  
~18 STPs from 11 cities captures methane (CPCB,2020)

## Objectives

1. To document existing methane capture technologies and process configurations adopted across operational STPs.
2. To analyse gas collection, handling, storage, and utilisation systems implemented for methane recovery.
3. To examine energy generation and resource reuse pathways, including electricity production, internal energy reuse, and sludge and treated effluent utilisation.
4. To assess financial sustainability, identify scalability opportunities, and understand key technical, operational, and governance challenges affecting methane recovery systems.

# The study captures various aspects of technology, operations, contractual agreements, financial models and monitoring

The study reviews treatment technologies, methane capture systems, operational arrangements, contract structures, financial models, and monitoring practices to understand how responsibilities, risks, and incentives shape performance and how the challenges are faced and what are the opportunities in this sector.



## 1. STP technology and methane capture type

- Types of STP technologies
- Methane capture methods



## 2. Operational and Contractual Arrangements

- Role and involvement of private operators and stakeholders
- Contract models
- Funding mechanisms and financing structures



## 3. Business and Financial Models

- Payment structures and revenue models (e.g., pay-per-unit methane, carbon credits)
- Risk mitigation and allocation (technical, financial, operational)



## 4. Monitoring and Performance Evaluation (identified opportunities and challenges)

- Monitoring mechanisms
- Performance evaluations in terms of identified opportunities and challenges

- 1. STP Technology and methane capture type:** various treatment technologies, methane capture systems, and wastewater characteristics were assessed to understand how technology selection, sludge digestion, methane leakage, and energy conversion influence methane recovery performance.
- 2. Operational and contractual arrangements:** Operational arrangements and contractual structures were examined to understand how responsibilities, incentives, risk allocation, and technical capacity affect methane generation and utilisation.
- 3. Business and financial models:** Business models were analysed to assess the financial viability of methane recovery systems, including revenue generation opportunities, cost recovery mechanisms, market linkages, and resource recovery pathways.
- 4. Monitoring and Performance evaluation:** Monitoring systems and plant performance were evaluated to identify operational constraints and highlight opportunities for improving methane utilisation and energy recovery.

# The approach for the study is detailed literature review followed by site visits and in-depth discussion with relevant stakeholders

The study combines literature review, field diagnostics, operator interviews, and performance assessments to understand methane potential, identify operational barriers, and outline viable pathways for resource recovery. It aims to strengthen design considerations for future methane capture and reuse systems. By combining data review with on-ground observations and stakeholder discussions, the study builds a holistic understanding of real operating conditions.

Understanding how different treatment processes influence methane generation is essential for designing climate-responsive wastewater systems. Though India has over **1,469 STPs**, **only 18 in 11 cities** currently capture methane. This gap underscores the need to analyse sludge characteristics, treatment technologies, plant efficiency, reuse markets, and governance frameworks that affect methane recovery.

Eleven cities with methane recovery units were identified, and six STP are selected for the study: Jaipur, Ahmedabad, Surat, Pimpri Chinchwad, Delhi and Nashik. These cities were visited for detailed documentation based on technology type, scale, operational approach, and reuse practices. A structured checklist and questionnaire guided site assessments, enabling comprehensive analysis of affecting factors, challenges, and opportunities.



# Scope and Limitations of the Study

## Scope

- The study assesses methane generation, capture, utilisation, and energy recovery performance across selected Indian STPs with biogas recovery systems.
- The assessment covers technical, operational, governance, business model, and monitoring dimensions influencing methane recovery outcomes.
- Performance evaluation is based on plant design characteristics, operational data, stakeholder consultations, and field observations.
- The study examines opportunities for improving methane recovery, reducing emissions, and enhancing resource recovery through electricity generation, CBG production, treated wastewater reuse, and sludge reuse.

## Please note:

- The findings should be interpreted as operational and policy insights to support decision-making and identify improvement opportunities, rather than as performance benchmarks applicable to all STPs.

## Limitations

- The study is based on a limited number of documented case studies and may not represent all STPs operating in India.
- Data availability and quality varied across cities, particularly for methane generation, methane leakage, and energy performance indicators.
- Direct methane leakage measurements were not available for all plants; therefore, some observations are based on performance indicators and stakeholder inputs.
- Financial and business model assessments are based on current operational conditions and do not account for future policy changes, carbon markets, or energy price fluctuations.
- Co-digestion, CBG production, and carbon credit opportunities were assessed primarily through stakeholder consultations and secondary literature, as these pathways are not yet widely implemented across the studied cases.
- The study focuses on methane recovery within STP boundaries and does not undertake a full life-cycle assessment of greenhouse gas emissions across the entire wastewater value chain.



# Contents

- 1 Overview- Need and Study approach
- 2 Documentation of existing methane capture and reuse practice
- 3 Key findings and learning –  
*Affecting factors, Challenges, Opportunities*  
Way forward

# Cities having STPs with methane capture unit shortlisted for the study

## Ahmedabad

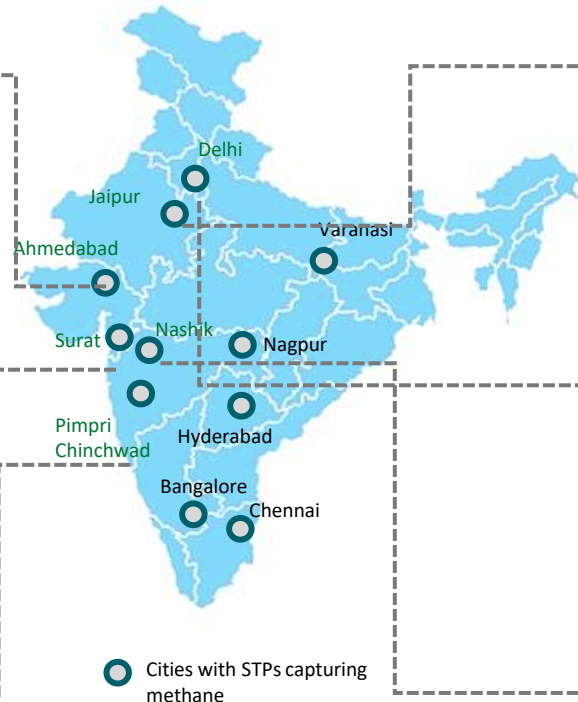
- Pirana and Vinzol Sewage Treatment Plants(STPs)
- 155 MLD and 100 MLD respectively – both 100% Utilised
- **Aerobic technology- SBR technology**
- Methane is reused to generate electricity, utilised to run both the STPs

## Surat

- **Anjana STP**
- 122 MLD- 100% Utilised
- Aerobic technology- SBR technology
- Methane reused to generate electricity, utilised to run STP

## PCMC

- Akurdi STP
- 30 MLD- 100% Utilised
- Aerobic technology- Combitreat technology-
- Small sized plant
- Methane reused to generate electricity, utilised to run STP



## Jaipur

- Delawas STP
- 215 MLD- 60% Utilised
- Aerobic technology- SBR technology
- Methane reused to generate electricity, utilised to run STP and sold to nearby private operator for bottling plant

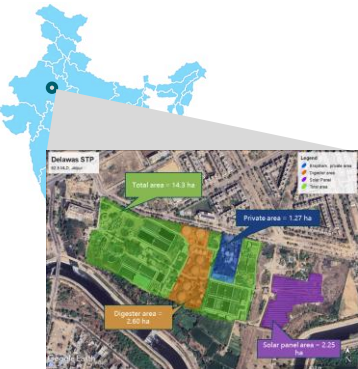
## Delhi

- Okhla STP
- 134 MLD- 50% Utilised
- Aerobic technology- **ASP technology**
- Methane reused to generate electricity

## Nashik

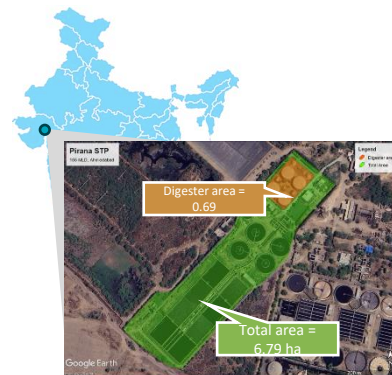
- Tapovan STP
- 130 MLD- 100% Utilised
- Anaerobic technology- UASB technology
- Oldest plant amongst other documented cases
- Methane reused to generate electricity and reused to run STP

# Overview of Selected STP Case Studies (1/2)



**Jaipur- Delawas STP- 215 MLD**

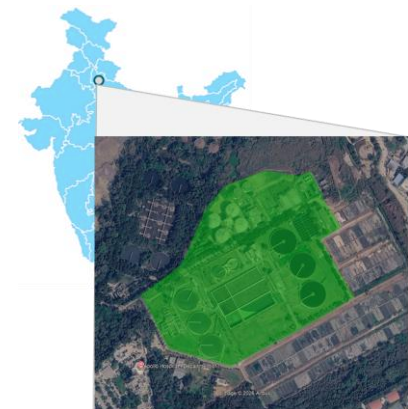
- As per the Census 2011, the current population of Jaipur is 3.05 million
- As of 2023, the projected population is 4.21 million
- Total water supplied in the city is 495 MLD
- Sewerage coverage of a city is 70 %
- Total Sewage generation is 400 MLD coming from 50% of the total seweraged area.
- **Delawas STP is located in the southern part of the city and receives about 50 % of the total sewage load i.e., 130 MLD at STP. It is one of the largest STPs.**
- **The utilisation of STP is 60%.**
- There are three STP units constructed and renovated over time. All three units have SBR treatment technology with different treatment capacities. Two units have a 62.5 MLD treatment capacity, and 1 unit has a 90 MLD treatment capacity. All three STP units became functional in 2023 under the DBOT contract.
- Since the STP is currently utilized at 60% capacity, only two units are functioning fully to treat 130 MLD of sewerage.
- The STP also runs on electricity generated from the 1.5 MW solar plant installed on-site.



**Ahmedabad- Pirana STP- 155 MLD**

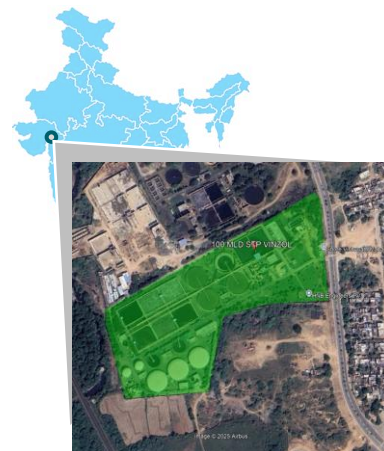
- As per the Census 2011, the current population of Ahmedabad is 5.5 million
- Total water supplied in the city is 1720 MLD (AMC,2026)
- Sewerage coverage of a city is 97 %\*
- Total Sewage generation is 1340 MLD (AMC,2026)
- A total of 155 MLD of wastewater is received at Pirana STP (11% of total sewerage generation).
- This STP was commissioned in 2021 under an EPC contract with 10 years of O&M contract given to a private operator.

\*Source: PAS-SLB 2025



**Delhi- Okhla STP - 136.4 MLD**

- Population (census 2011) - 167.87 lakhs
- Current population (2024) - 346 lakhs
- Delhi's water supply, managed by the Delhi Jal Board, is produced at a capacity of approximately 2,911 MLD (DJB,2025)
- Total Sewage generation - 2832 MLD(DJB,2025)
- Okhla STP Plant of capacity 136.4 MLD
- This is the 6th number plant established by DJB.
- Total plant area- 20 Hectare



**Ahmedabad- Vinzol STP - 100 MLD**

- As per Census 2011, the current population of Ahmedabad is 5.5 million
- Total water Supplied in the city is 1720 MLD (AMC,2026)
- Sewerage coverage of a city is 97 %\*
- Total Sewage generation is 1340 MLD (AMC,2026)
- Total 100 MLD of wastewater is received at Vinzol STP (~6% of total sewerage generation). This STP was commissioned in 2022 under EPC contract with 10 years of O&M contract given to a private operator.

# Overview of Selected STP Case Studies (2/2)



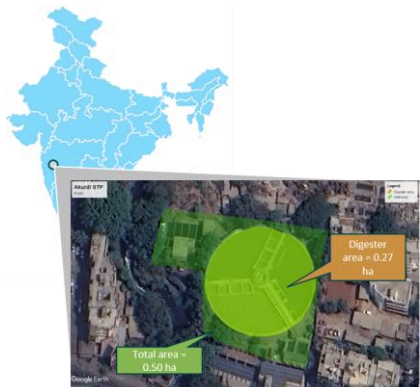
**Surat- Anjana STP- 122 MLD**

- As per the Census 2011, the current population of Ahmedabad is 0.98 million
- As per 2023, the projected population is 8.23 million
- Total water supplied in the city is 1611 MLD
- Sewerage coverage of a city is 99 %
- Total Sewage generation is 1063 MLD.
- Total 122 MLD of wastewater is received at Anjana STP (11.5% of total sewerage generation)
- This STP was commissioned in 2003 under an EPC contract and has been operated by different private operators since then. The O&M contracts were of 10 years for each private operator.
- Treated water disposed of in Khadi
- Sludge is being dumped at a sanitary landfill after being used for the production of electricity in an anaerobic digester



**Nashik- Tapovan STP- 130 MLD**

- As per Census 2011, the current population of Nashik is 1.5 million
- As per 2023, projected population is 2.3 million
- Total water Supplied in the city is 550 MLD
- Sewerage coverage of a city is 99 %
- Total Sewage generation is 285 MLD.
- Total 130 MLD of wastewater is received at this STP with UASB technology.
- The plant has a capacity 130 MLD and commenced operations in 2003. It is located near the Godavari River at Tapovan, Panchavati in Nashik. The facility was initially designed, constructed & operated by GS Jolly (78 MLD) and Gondwana (52 MLD), and is currently operated by Mahajan Brothers.



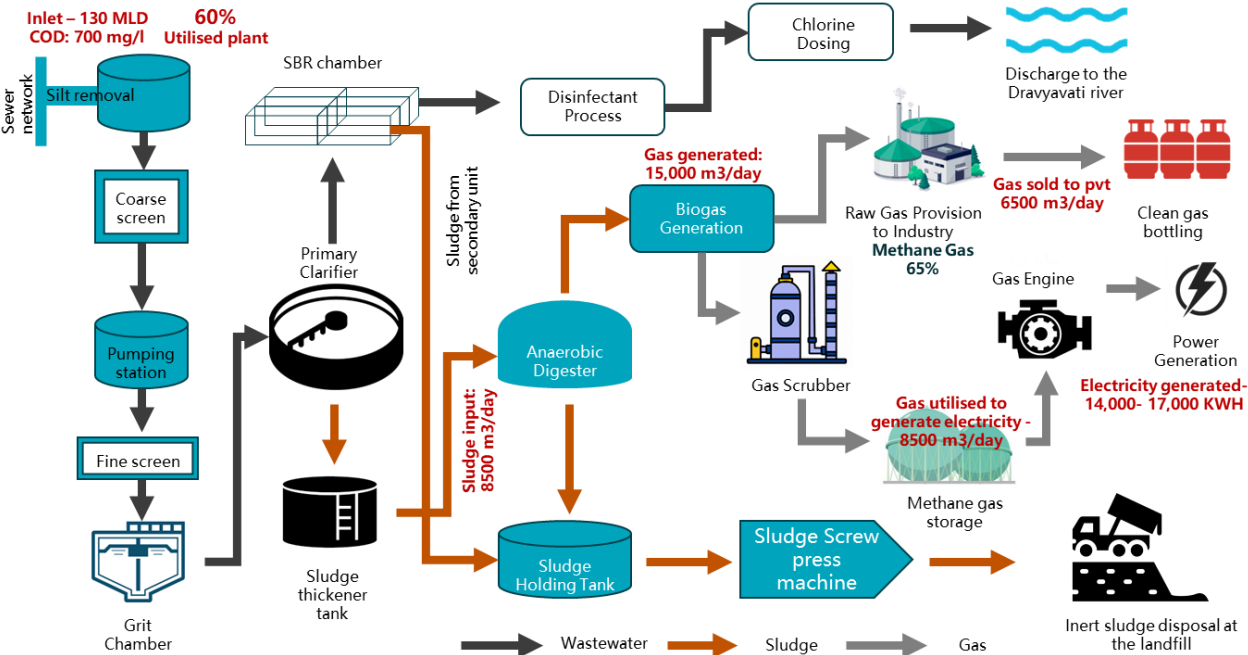
**PCMC- Akurdi STP – 30 MLD**

- As per the Census 2011, the current population of Ahmedabad is 1.7 million
- As per 2023, the projected population is 3.6 million
- Total water supplied in the city is 615 MLD
- Sewerage coverage of a city is 96 %
- Total Sewage generation is 492 MLD.
- A total of 155 MLD of wastewater is received at Pirana STP (11% of total sewerage generation). This STP was commissioned in 2021 under a DBOT contract with 10 years of O&M contract given to a private operator.

# 1. STP technology and methane capture type

Various treatment technologies, methane capture systems, and wastewater characteristics were assessed to understand how technology selection, sludge digestion, methane leakage, and energy conversion influence methane recovery performance.

# 1. Jaipur – Delwas STP -215 MLD



- Primary treatment:** Sewerage water passes through a silt removal unit first, as there is an issue of silting in the wastewater that chokes the STP treatment units. From that, WW goes for screening and grit removal chambers.
- Secondary treatment:** From the grit chamber, wastewater goes to the primary clarifier. From here, the wastewater goes to the SBR unit, disinfection unit, and chlorine dosing unit. The treated water is sent to the nearby NRI housing colony for gardening as per their requirement at no cost, and the rest is discharged in the Dravyavati river.
- Sludge treatment:** Sludge from only the primary clarifier goes to the sludge thickener tank for thickening the sludge. From there, it goes to an anaerobic digester, where ~15000 m<sup>3</sup>/day biogas is generated.
- From here, the ~6500 m<sup>3</sup>/day raw gas is sold to nearby private industry. The remaining ~8500 m<sup>3</sup>/day gas goes to gas scrubber where the H<sub>2</sub>S is removed. From there, the gas is stored in gas holding balloons.
- Biogas generated here** has 65% methane in it, which is used to generate ~14k-17k Unit/day power. This is used to run the STP. The STP also runs on electricity generated from solar plant installed at STP.

**Process Flow Diagram- SBR technology**

Source: The authors' illustration based on the field visit

# About Methane gas generation and reuse at Delawas STP



**Inlet**



**Primary Clarifier**



**Thickener Tank**



**SBR Tanks**



**Gas holding Balloons**



**Discussion with Operators**



**Pumping station**



**Digester**



**Sludge Screw Press**



**Gas Scrubber**

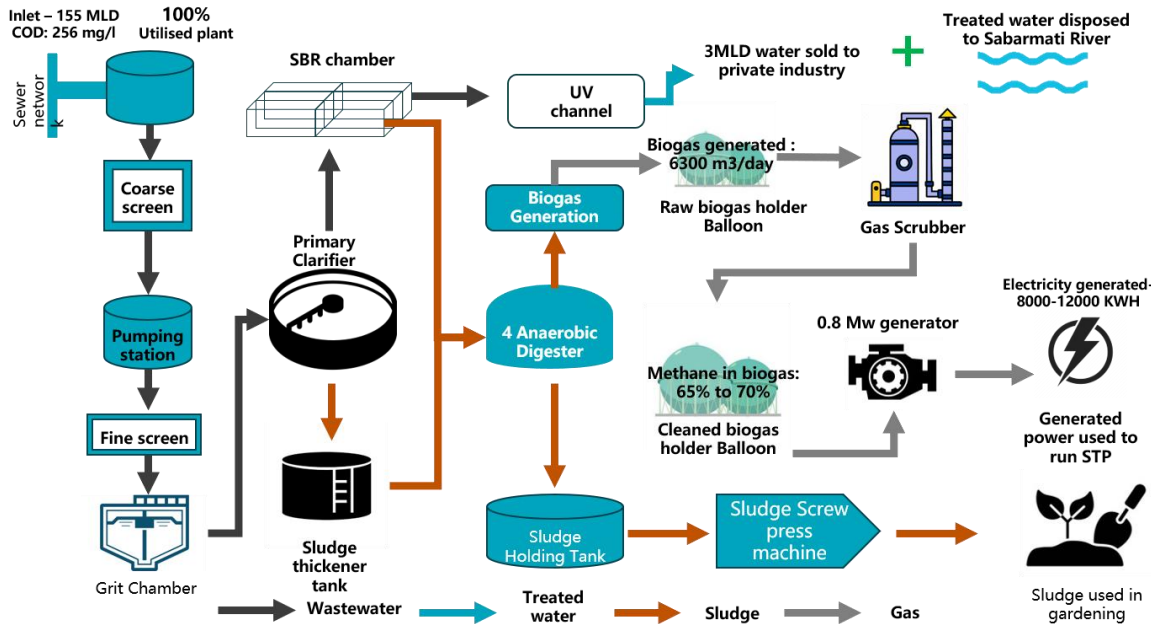


**Gas Engine**

**Reuse :**  
 Sludge – Methane and electricity generation  
 Wastewater – To the nearby NRI housing colony and the rest is discharged in the Dravyavati river

- **Sludge line:** Sludge from sequential batch reactors and the anaerobic digester goes to sludge holding tank and from there it goes to sludge screw press machine. From here the inert sludge disposed at landfill.
- Total average volume of biogas generated at Anaerobic digester is 15000 m3/day. Biogas yield is 70m3/ML
- The ULB has an agreement of selling 6500m3/day raw biogas to the private operator of bottling gas plant located adjacent to the STP site.
- Total electricity requirement to run the STP is 26,000-27,000 Unit/day. Meeting 63% of the electricity demand of STP.
- After giving 6500m3/day gas to private operator, remaining (15000-6500=8500) 8500m3/day volume of gas is used to generate maximum 17,000 Unit/day electricity through gas engine and utilised at STP.
- Solar plant of 1.5 MW installed at STP generates 5000 unit/day electricity, utilised to run the STP.
- Remaining electricity requirement is sufficed by Jaipur Nagar Nigam (JNN) from the grid. JNN provides maximum of 17,415 Unit/day at free of cost. It's a cap set by JNN. In case of less gas generation results to less electricity generation- STP takes more than 17,415 units/day from the grid at the cost of 10rs/unit.

## 2. Ahmedabad - Pirana STP- 155MLD



Process Flow Diagram-SBR technology

- **Primary treatment:** Sewerage water passes through screening and grit removal chambers.
- **Secondary treatment:** From the equalization tank, wastewater goes to the primary clarifier. From here, the wastewater goes to the SBR unit, disinfection unit, and UV system. The treated water is disposed of in the Sabarmati River. 3MLD-treated water is sold to a nearby private operator and used as a coolant.
- **Sludge treatment:** Sludge from the primary clarifier goes and sludge settled at the bottom of the SBR unit goes to the sludge thickener tank. From there it goes to an anaerobic digester where 4000-6500 m3/day biogas is generated.
- The raw gas goes to the scrubber, where the H<sub>2</sub>S is removed. From there, the gas is stored in gas holding balloons.
- **Biogas generated** here has 63% methane in it, which is used to generate electricity. Around 8000-12,000 units/day of power is generated, which is used to run the STP. This meets around 40% of the total electricity required to run the STP.
- **Sludge line:** Sludge from the anaerobic digester goes to the sludge holding tank, and from there it goes to the sludge screw press machine. This dewatered sludge is reused as a fertilizer in the landscaped areas of STP.

# Pirana STP- 155 MLD, Ahmedabad



Collection, screening and grit removal



Primary treatment- Clarifloculator



Sludge thickening tank



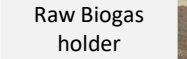
Sludge digester



H2S scrubber



Clean Biogas holder



Raw Biogas holder



Electricity generation through gas engine



62.5% methane in total generated biogas

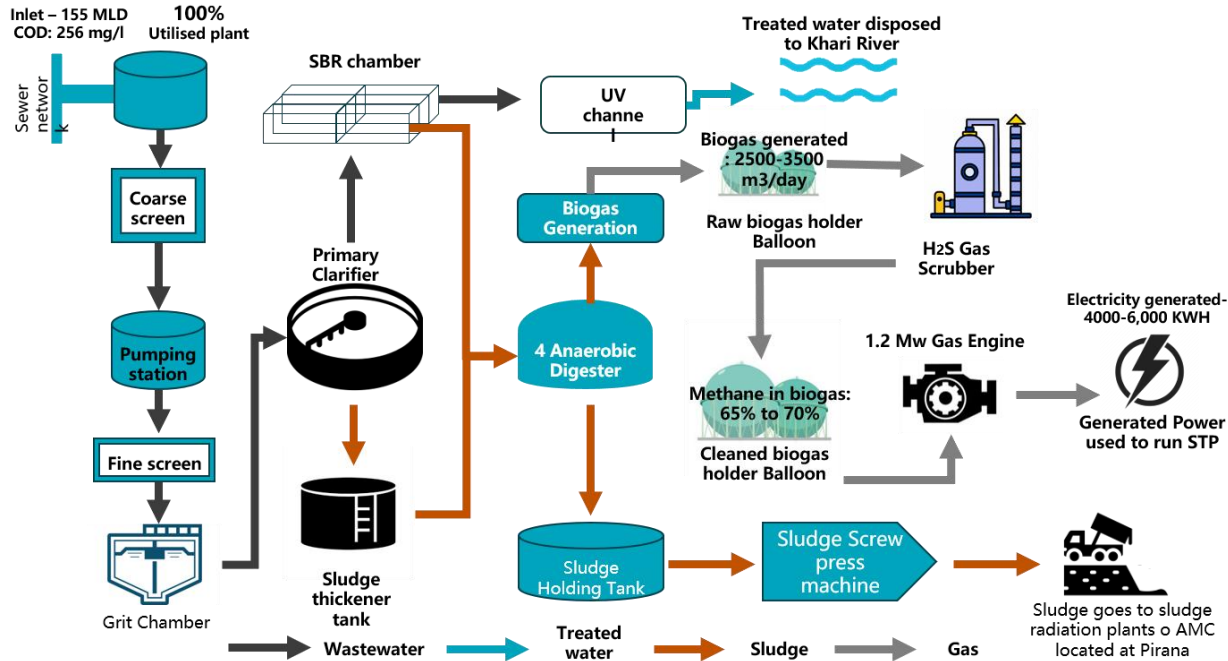


Discussion with STP operator



Discussion with Private Contractor

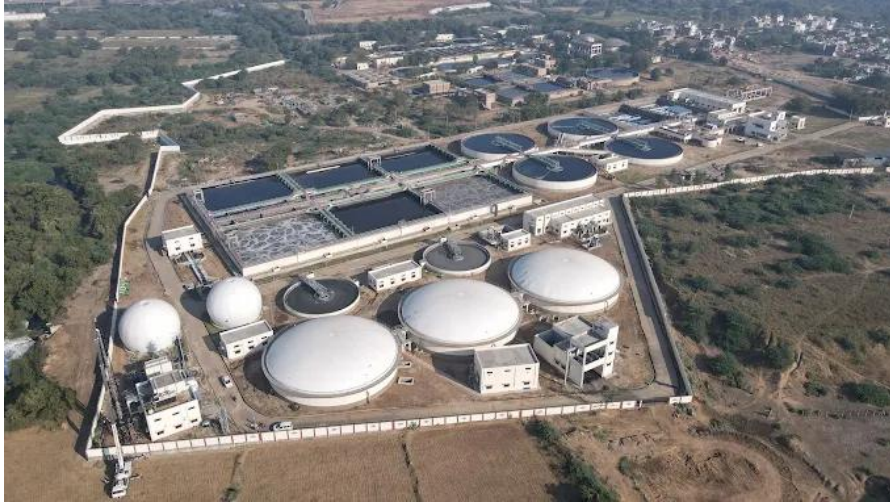
# 3. Ahmedabad – Vinzol STP - 100 MLD



Process Flow Diagram- SBR technology

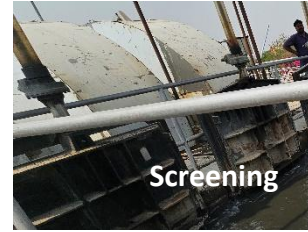
- Primary treatment:** Sewerage water passes through screening and grit removal chambers and goes to the equalization tank.
- Secondary treatment:** From the equalization tank, wastewater goes to the primary clarifier. From here, the wastewater goes to the SBR unit, disinfection unit, and UV system. The treated water is disposed of in the Khari River.
- Sludge treatment:** Sludge settled at the primary clarifier, and sludge settled at the bottom of the SBR unit goes to the sludge thickener tank. From there it goes to an anaerobic digester where 2,500-3,500 m<sup>3</sup>/day biogas is generated.
- The raw gas is stored in a raw gas holder balloon, and from there it goes to the scrubber, where the H<sub>2</sub>S is removed. Then the cleaned gas is stored in clean gas holding balloons.
- Biogas generated** here has 65%-70% methane in it, which is used to generate electricity. Around 4000-6000 units/day of power is generated, which is used to run the STP. This meets around 30% of the total electricity required to run the STP.
- Sludge line:** Sludge from the anaerobic digester goes to the sludge holding tank, and from there it goes to the sludge screw press machine. This dewatered sludge is then sent to the sludge radiation plant of AMC located at Pirana for further treatment and reuse.

# Vinzol 100 MLD STP – Brief Overview



## STP Plant premises Profile :

- **Total Capacity:** 100 MLD (Commissioned in 2022)
- **Technology Used:** Sequential Batch Reactor (SBR)
- **Utilization:** Currently operating at around 100% capacity.
- **Contract & Operation:** Developed under EPC model, designed, constructed and operated by private operator with 10 years of O&M Contract.
- **Biogas Experience:** The quality of wastewater is not received as per the quality of wastewater parameters the design of the Plant, reduced COD leads to reduced generation of biogas.



Screening



Equalisation tank



Primary clarifier



Aeration tank



Sludge thickening tank

Anaerobic Digester



Discussion with AMC official



Raw gas storage balloon

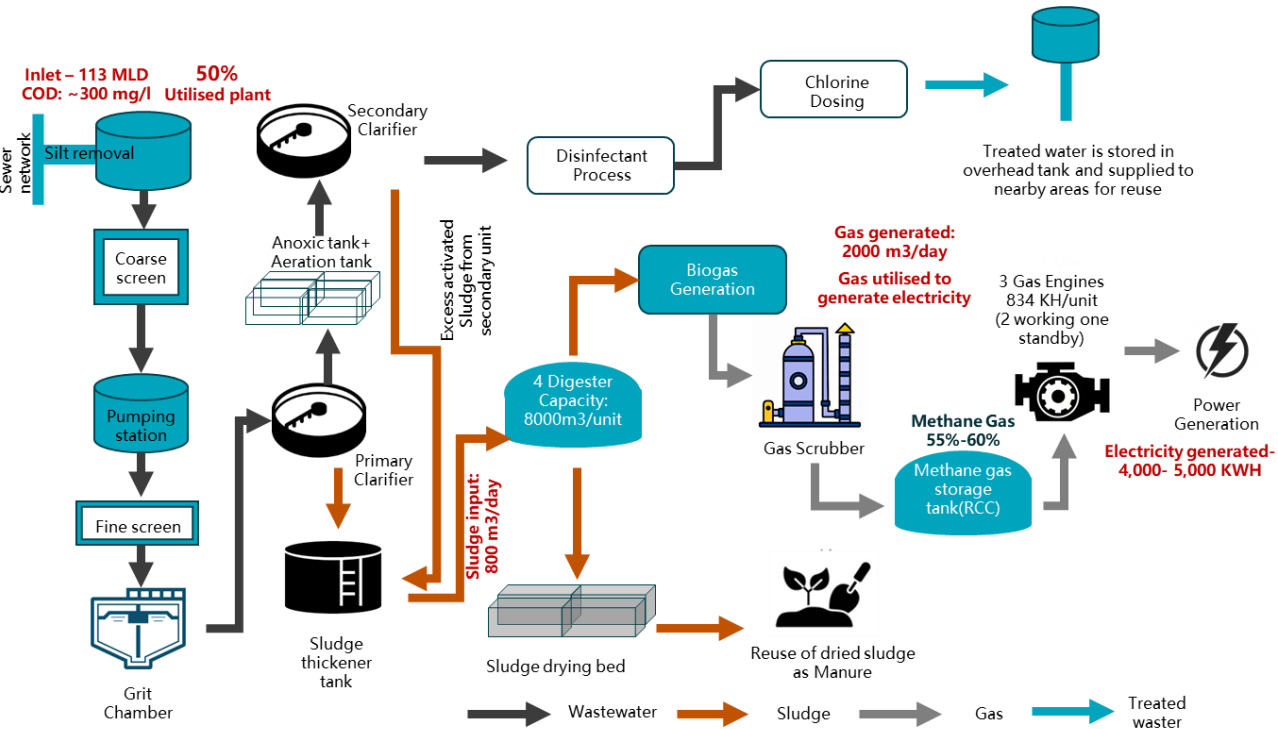
Scrubber

Cleaned gas storage balloon



Discussion with Private STP operator

# 3. Delhi – Okhla STP - 113 MLD



- **Primary treatment:** 113 MLD Sewerage water passes through screening and grit removal chambers.
- **Secondary treatment:** From grit chamber wastewater goes to primary clarifier. From here the wastewater goes to Anoxic tank to Aeration tank. From there water goes to secondary clarifier and to chlorine dosing unit. The treated water is then stored in an overhead tank after softening the water.
- **Sludge treatment:** Sludge settled at the bottom of primary and secondary clarifier pumped to sludge thickener tank. From there it goes to Anaerobic digester where ~2000 m<sup>3</sup>/day biogas is generated.
- The raw gas goes to scrubber where the H<sub>2</sub>S is removed. From there the gas is stored in gas holding tank(RCC).
- **Biogas generated** here has 60% methane in it which is used to generate electricity. Around 4000-5000 unit/day power is generated which is used to run the STP. This meets around ~25-30% of the total electricity required to run the STP.
- **Sludge line:** Sludge from anaerobic digester goes to sludge drying beds and from there dried sludge is used as Manure and sold to farmers at free of cost.

## Process Flow Diagram-ASP technology

Source: The authors' illustration based on the field visit

# Okhla STP – Brief Overview

## STP Plant premises Profile :

- **Total Capacity:** 113 MLD (2012)
- **Technology Used:** Activated Sludge Process (ASP)
- **Utilization:** Currently operating at around 50% capacity.
- **Contract & Operation:** Developed under DBOT model, designed by SUEZ and operated under Delhi Jal Board. Contract renewed in 2023.
- **Biogas Experience:** Earlier plants supplied biogas to nearby houses, but due to irregular supply, technical issues, and high O&M costs, the supply was discontinued. ASP technology was selected as it generates comparatively more biogas.



Inlet



Screening



Primary Clarifier



**Reuse :**  
Sludge – Methane and electricity generation  
Treated wastewater is reused for horticulture and landscaping

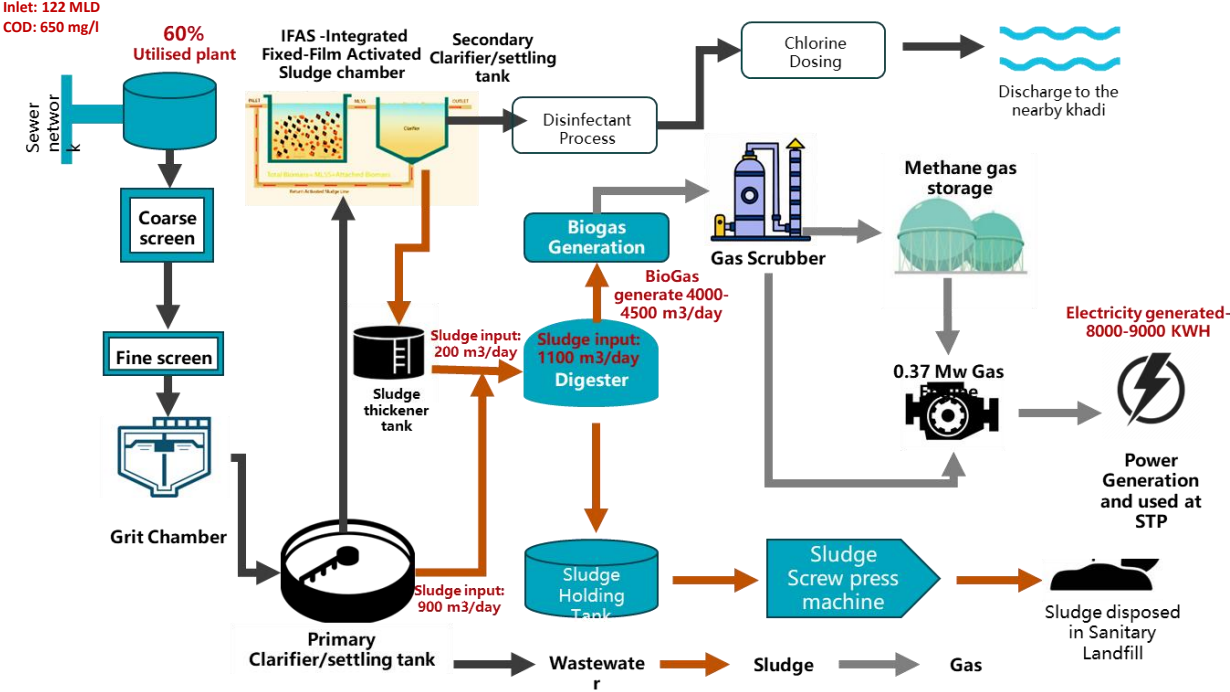


Digester



Discussion with DJB

# 4. Surat- Anjana STP- 122 MLD



**Process Flow Diagram-IFAS technology**

Source: The authors' illustration based on the field visit

- Primary treatment:** Sewerage water passes through silt removal unit first as there is an issue of silting in the wastewater that chokes the STP treatment units. From that WW goes for screening and grit removal chambers.
- Secondary treatment:** From grit chamber wastewater goes to primary clarifier. From here the wastewater goes to IFAS chamber and from there to secondary clarifier to disinfection unit and chlorine dosing unit. The sludge from secondary clarifier goes to sludge thickening tank and sludge from primary clarifier and sludge thickener tank goes to Anaerobic Digester.
- At Anaerobic digester around 4500 m3/day biogas is generated.** From here gas goes to scrubber where the H<sub>2</sub>S is removed. From there the gas is stored in gas holding balloons.
- Biogas generated here** has 71% methane in it which is used to generate ~8000-9000 Unit/day power. This is used to run the STP. The power generated from the methane gas helps to meet 41% of the power required to run the STP.

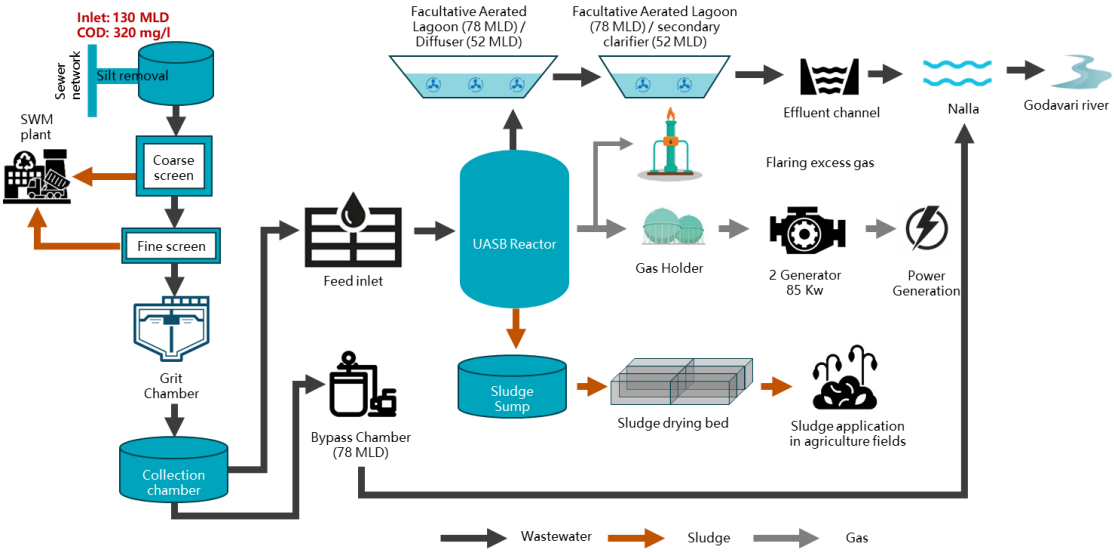
# Surat- Anjana STP -122 MLD- IFAS technology

- Total 122 MLD of wastewater is received at Anjana STP (11.5% of total sewerage generation)
- This STP was commissioned in 2003 under an EPC contract and has been operated by different private operators since then. The O&M contracts were of 10 years for each private operator.
- Electricity is generated by a generator of 0.36 MW capacity, with a low Electricity generation potential of 2.8 kWh/m<sup>3</sup> CH<sub>4</sub>
- Treated water disposed of in Khadi
- Sludge is being dumped at a sanitary landfill after being used for the production of electricity in an anaerobic digester



# 5. Nashik – Tapovan STP -78 MLD and 52 MLD

Process Flow Diagram- UASB technology



Treatment units with capacity	78 MLD	52 MLD
Utilisation	100%	100%
Technology	UASB + Surface Aeration	UASB + Diffuse Aeration
Secondary treatment of water technology	UASB > Aeration tanks (12 Aerators) > Polishing Pond > Final Effluent Channel > Chlorination > Nalla > Godavari River	UASB > Clarifloculator (Diffuser system) > Secondary clarifier > Final Effluent Channel > Chlorination > Nalla > Godavari River
Sludge drying beds	32	12
Year of commission	2003	2010
Contract type	DBOT	DBOT
Gas Holder	1 Unit: MS dome	1 Unit: MS dome

- **Primary treatment:** Raw sewage arrives and passes through the inlet chamber, where coarse screening and grit removal take place to eliminate large particulates and inorganic grit.
- **Secondary treatment:** UASB Reactor: Sewage is distributed into multiple UASB reactor tanks where anaerobic digestion occurs. Organic matter is degraded by anaerobic microbes in an up-flow pattern, forming a sludge blanket. Methane-rich biogas produced is collected for energy use. This stage handles high organic load efficiently and reduces COD without oxygen.
- Aeration Tank: Post-UASB treatment, the effluent moves to aerobic tanks where dissolved oxygen is introduced by mechanical aerators with multiple aerators operated by motors. The aeration types are different in the 78 MLD and 52 MLD plants, as shown in the table above.
- Polishing Pond: The aerated water is settled in polishing ponds, and finally, the treated water undergoes disinfection via **chlorination**, where chlorine is added to kill pathogenic microorganisms before discharge or reuse.
- **The biogas** produced during the anaerobic digestion of organic pollutants in the UASB reactors is captured under gas collection MS domes. Around 3000-4000 m<sup>3</sup>/day of biogas is generated in the UASB. It has 71% of methane in biogas.
- **Then, the sludge** from the UASB goes to the sludge drying bed. The dried sludge is used for agricultural purposes. The treated water is disposed of in the Godavari River

# Tapovan STP– Brief Overview

## STP Profile :

- **2 units** – 78 MLD & 52 MLD
- **Total Capacity** – 130 MLD; spread in 13 hectares (32 acres)
- **Utilization** – 100%
- Managed by a private operator on the DBOT model for 5 years and contract has been extended for 2 years
- UASB will be replaced by a new SBR-based STP in the same premises, as the existing plant is fully utilized. Officials opted for the SBR technology as it requires less space and provides efficient treatment.



Inlet



Screening



Outlet after screening



UASB reactor



Polishing Pond

## Reuse :

- **Sludge** – Methane and electricity generation
- **Treated wastewater** is disposed into Godavari river
- **Sludge** is given to farmers at free of cost



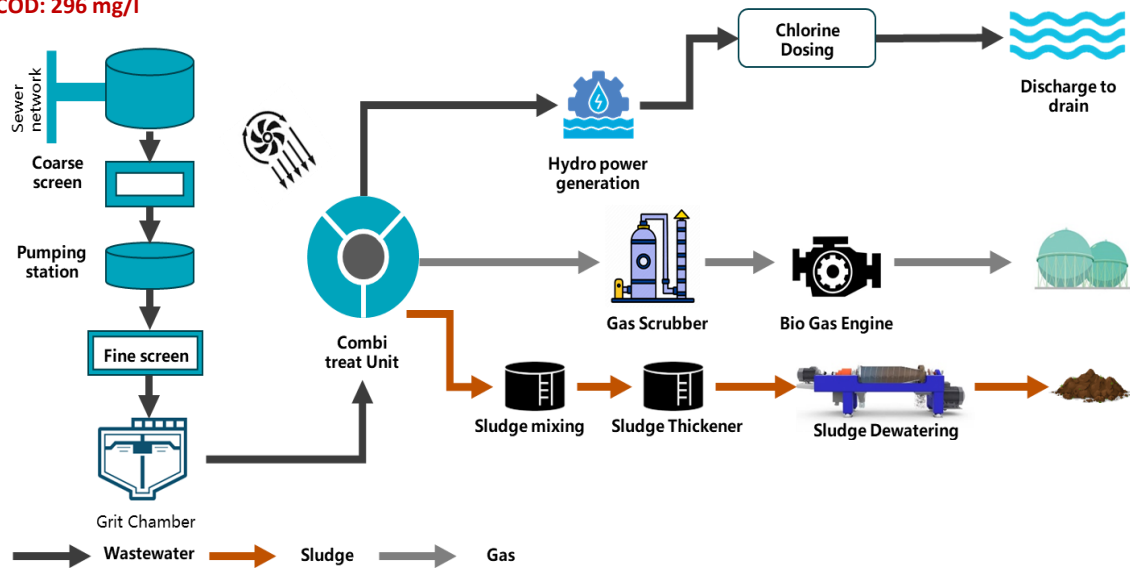
Biogas room



Inhouse lab

# 6. Pimpri Chinchwad– Akurdi STP - 30 MLD

Inlet: 30 MLD  
COD: 296 mg/l



Process Flow Diagram - Combiteat technology

Source: The authors' illustration based on the field visit

- **Primary treatment:** Sewerage water passes through silt removal unit first as there is an issue of silting in the wastewater that chokes the STP treatment units. From that WW goes for screening and grit removal chambers.
- **Secondary treatment:** From grit chamber wastewater goes to Combiteat unit of STP. Wastewater from here goes to Combiteat unit (anaerobic core). Flow enters a central zone of Combiteat where sludge settles and is anaerobically digested to generate methane-rich biogas collected under a floating dome; clarified liquid overflows to the aeration stage while high-strength sludge remains for digestion.
- **Aerobic polishing (constant-level SBR/CLSBR):** The overflow is treated in batch reactors operating fill–react–settle–discharge sequences at constant liquid level, improving energy efficiency and maintaining head for downstream energy recovery. Treated effluent is chlorinated in a contact tank.
- **Sludge line:** Excess sludge is thickened, then dewatered by centrifuge before disposal or further handling.
- Significant on-site power coverage through combined biogas-to-power and hydropower recovery. **25% of treatment power demand can be met internally.**

# PCMC Akurdi 30 MLD STP - Combiteat I - SBR technology



Flair Unit



Incoming Sewer and pumping station



Screen and Grit chamber



Combiteat unit with 3 Basins



Gas capture balloon over Combiteat unit



Sludge Blending tank



Centrifuge



Chlorination & outlet

# Summary: Technology must minimise leakage while ensuring effluent quality compliance.

Across the studied cities, methane recovery performance is strongly influenced by technology choices and system design. Plants with improved components and gas-tight systems demonstrate better methane capture, while older configurations face higher losses.

## Supporting Observations

- Balloon gas holders (Jaipur, Ahmedabad) show lower methane leakage compared to RCC holders (Delhi, Nashik, Surat).
- Advanced systems (Vinzol Ahmedabad, Delhi upgrades) improve operational stability and reduce losses.
- UASB plants (Nashik, PCMC) show high methane content but lower recovery efficiency.
- Methane utilisation is largely limited to electricity generation across cities.
- Methane capture across these plants is primarily used for electricity generation, with limited evidence of advanced gas upgrading or purification technologies such as CBG production. This highlights a gap and opportunity for improving methane utilisation pathways.



## 2. Operational and Contractual Arrangements

Operational arrangements and contractual structures were examined to understand how responsibilities, incentives, risk allocation, and technical capacity affect methane generation and utilisation.

# Operational and contractual agreement of Jaipur- Delawas STP



**DBOT contract with Private operator with 10 year of O&M contract, STP is owned by JNN**

ASSET



**Capital Cost**

**229.5 Cr.**

By ULB



**Human resource involved**

A team of **100 personnel**, ensuring **24x7** operations.



**O&M Cost**

**29 Lakhs/ month**

(with 10% increase in every year)

**Periodic maintenance of STP and fixed electricity unit cost is paid by ULB**



**To Construct and meet the operating performance requirements for 10 years as per contract**

**Reporting hierarchy:**

Private operator → Add. Chief Engineer → Executive Engineer (EE) of AMC → City Engineer → Municipal Commissioner

**Role of Private Operator**

## Penalties on

1. Biogas supply shortfall
2. Electricity generation shortfall



**STP Power Requirement**

**26,000- 27,000**

**Unit/Day**



**Power Generation From Biogas and Solar**



**MAX 17,000 Unit/day from 8500 m3/day gas**



**MAX 5,000 Unit/day**



**17,415 Unit/day~60% provided** by ULB- Fixed as per contract - bill is paid by ULB

- The STP is constructed and operated by a private operator. Under the DBOT contract mechanism. It was commissioned in 2023 and will be operated by a private operator for 10 years.as per the contract agreement. The capital cost is paid by ULB.
- The private operator raises monthly invoices, paid by the ULB.
- Approximately 44% of O&M costs are recovered through biogas sales
- The penalties imposed on the private operators helped the ULB to sustain the revenue generation and increase in case of defaulting on the generation of required gas.
- The ULB has agreed to pay the STP electricity bill on the decided cap, which motivates private operators to generate more electricity from biogas and meet the requirement in the given cap. Electricity generated from Solar is also varied depending on climatic conditions.
- In case of less electricity generation, the private operator must pay 10rs/additional unit required to ULB as a penalty.
- Presence of SCADA system helps the city and private operator to monitor and evaluate the performance and justify the requirements and defaults.

**~63 % electricity requirement is met by the electricity generated from gas and solar.**

# Operational and contractual agreement of Ahmedabad – Pirana STP



ASSET

**EPC contract** with Private operator with  
10 year of O&M contract, STP is owned by AMC



**Capital Cost**

**151 Cr.**  
By ULB



**O&M Cost**

**40 Lakhs/ month**  
Periodic maintenance of STP and fixed electricity unit cost is paid by ULB



**Human resource involved**

A team of **30 personnel**, ensuring 24x7 operations.



**Role of Private Operator**

To Construct and meet the operating performance requirements for 10 years as per contract

Reporting hierarchy:

Private operator → Add. Chief Engineer → Executive Engineer (EE) of AMC → City Engineer → Municipal Commissioner

- The STP is constructed and operated by private operator. Under EPC contract mechanism. It was commissioned in 2021 and will be operated by private operator for 10 years.as per the contract agreement. The capital cost is paid by ULB.
- 60% of the electricity requirement is taken from the grid. The electricity bill is paid by AMC.
- Presence of SCADA system helps the city and private operator to monitor and evaluate the performance and justify the requirements and defaults



**STP Power Requirement**

**18,000- 19,000**  
Unit/Day



**Power Generation From Biogas**



**MAX 8,000 Unit/day**  
~40% electricity requirement is met by the electricity generated from gas



Remaining electricity is taken from the Grid- Bill paid by AMC at 9 INR/Unit

# Operational and contractual agreement of Ahmedabad – Vinzol STP



ASSET

**EPC contract with Private operator with 10 year of O&M contract, STP is owned by AMC**



**Capital Cost**

**139 Cr.**  
By ULB



**O&M Cost**

**23 Lakhs/ month**  
Periodic maintenance of STP and fixed electricity unit cost is paid by ULB



**Human resource involved**

A team of **36 personnel**, ensuring 24x7 operations.



**Role of Private Operator**

**To Construct and meet the operating performance requirements for 10 years as per contract**

**Reporting hierarchy:**  
Private operator → AMC STP in charge Engineer → Add. Chief Engineer → Executive Engineer (EE) of AMC → City Engineer → Municipal Commissioner

- The STP is constructed and operated by private operator. Under EPC contract mechanism. It was commissioned in 2022 and will be operated by private operator for 10 years as per the contract agreement. The capital cost is paid by ULB.
- The private operator raises the bill every month that is being paid by AMC.
- The penalties imposed on the private operators helped the ULB to sustain the revenue generation and increase in case of defaulting in generation of required gas.
- ~30% of the electricity requirement is taken from the grid. The electricity bill is paid by AMC.
- Presence of SCADA system helps the city and private operator to monitor and evaluate the performance and justify the requirements and defaults



**STP Power Requirement**

**20,000 Unit/Day**



**Power Generation From Biogas**

**MAX 4,000-6,000 Unit/day**



**~30% electricity requirement is met by the electricity generated from gas**

Remaining electricity is taken from the Grid- Bill paid by AMC at 9 INR/Unit

# Operational and contractual agreement of Delhi – Okhla STP



ASSET

**DBOT Contract and Operated under:** Delhi Jal Board,  
O&M Period: 5 years (extended/renewed in 2022 for 11 years)



**Capital Cost**

**150 Cr** for  
136.4 MLD STP

Funded by  
JICA



**O&M Cost**

**87 Lakhs/ month**  
(with 10% increase every year)

Periodic maintenance of STP and electricity cost as per actual is paid by DJB



**Human resource involved**

A team of **72 personnel**, ensuring 24x7 operations.



**Role of Private Operator**

Plant currently operated & maintained by SUEZ Asset ownership remains with Delhi Jal Board

Reporting hierarchy:

Private operator → EE → CE of DJB → Municipal Commissioner

- The STP is constructed and operated by private operator.
- It is one of the oldest plant of Delhi. It was commissioned in 2012.
- Under DBOT contract mechanism. It was commissioned in 2012 and have been operated by private operator for 10 years, as per the contract agreement.
- The capital cost was paid by ULB.
- In 2025, it was renovated by a big private player and is being operated by this private operator
- Though it's an ASP technology but because of the material of gas holder the STP is generating electricity from the biogas.
- It only covers the 26% of cost is generated compared to total required electricity.



**STP Power Requirement**

**19,000- 20,000 kWh/Day**



**Power Generation From Biogas**



**MAX 4000-5000 kWh/day generation from gas**



**14,000 -15,000 kWh/day**

**~70% provided by DJB**

from the grid to STP

~25-30% electricity requirement is met by the electricity generated from gas.

## Penalties on

If grid consumption exceeds the permitted limit i.e. 26,500 kWh as per the contract, a penalty of ₹10–12 per kWh is charged, depending on peak or lean hour usage.

# Operational and contractual agreement of Surat- Anjana STP



**EPC contract with Private operator with 10 year of O&M contract, STP is owned by SMC**



**103 Cr.**

**Capital Cost**

By ULB



**O&M Cost**

**Periodic maintenance of STP and fixed electricity unit cost is paid by ULB**

(with 10% increase every year)



**Human resource involved**

A team of 4-5 SMC, 40 Private staff, ensuring 24x7 operations.



**Role of Private Operator**

To Construct and meet the operating performance requirements for 10 years as per contract

Reporting hierarchy:

Private operator → SMC STP executive engineer → Sanitation department → City Engineer

- The STP is constructed and operated by private operator. Under EPC contract mechanism with the contract to operate and maintain the STP or the next 10 years. It was one of the oldest STP. It was commissioned in 2013. At present, it is operated by the private operator.
- Private operator raise the bill every month that is being paid by ULB.
- The penalties imposed on the private operators helped the ULB to sustain the revenue generation and increase in case of defaulting in the generation of required gas.
- 60% of the electricity requirement is taken from the grid. The electricity bill is paid by SMC.
- Presence of SCADA system helps the city and private operator to monitor and evaluate the performance and justify the requirements and defaults

## Penalties on

- Operational hours of the biogas plant per year
- Electricity generation shortfall per year



**STP Power Requirement**

**20,000-22,000**

**Unit/Day**



**Power Generation From Biogas and Solar**

**MAX 8000-9000 Unit/day from 4000-4500 m3/day gas**

**~41% electricity requirement is met by the electricity generated from gas and solar,**



**Remaining 12,000 Unit requirement met and paid by SMC**

# Operational and contractual agreement of Nashik – Tapovan STP



**DBOT contract with Private operator with 5 years + 2 years extended of O&M contract, STP is owned by NMC**



**28.82 Cr for 2 STPs**

**Capital Cost**

Godavari action plan and JNNUM



**7.5 Lakhs/ month – 78 MLD  
12.51 Lakhs/month – 52 MLD  
(with 10% increase every year)**

**O&M Cost**

**Periodic maintenance of STP and fixed electricity unit cost is paid by ULB**



A team of **30-40 personnel**, ensuring 24x7 operations.

**Human resource involved**



**To Construct and meet the operating performance requirements for 10 years as per contract**

**Role of Private Operator**

**Reporting hierarchy:**

Private operator → Chief Engineer → Executive Engineer (EE) of AMC → City Engineer → Municipal Commissioner



**STP Power Requirement**

**3,000- 4,000 Unit/Day**



**Power Generation From Biogas**



**MAX 167 Unit/day from 246 m3/day gas**

**~Only 5% electricity requirement is met by the electricity generated from gas.**



**3166 Unit/day- ~95% bill is paid by ULB**

**• No Penalty related to biogas or Electricity generation**

- The STP is constructed and operated by a private operator under a DBOT contract.
- Two units with capacity of 78 MLD (commissioned in 2003) and 52 MLD (commissioned in 2010) the plant will be operated privately for five years as per the agreement.
- The capital cost of the plant has been fully paid by the ULB.
- The private operator raises monthly invoices, which are paid by the ULB.
- Only about 5% of the plant's electricity demand is met through gas-based power generation. The remaining electricity cost is borne by the city.
- The absence of a SCADA system limits real-time monitoring and makes performance improvement difficult. The operator cannot accurately monitor gas production or electricity generated from it.
- Oversight is limited as the contract does not include clauses on sludge management or electricity generation.

# Operational and contractual agreement of PCMC – Akurdi STP



**DBOT contract** with Private operator  
with 5 year of O&M contract, STP is  
owned by PCMC



**29.25 Cr.**  
By ULB



**3-4 Lakhs/ month**  
(with 10% increase every year)

**Periodic maintenance of STP and 2 pumps operated by electricity generated at STP**

**Capital Cost**

**O&M Cost**



A team of **25 personnel**, ensuring 24x7 operations.



**To Construct and meet the operating performance requirements for 5 years as per contract**

**Reporting hierarchy:**

Private operator → Junior Engineer → Executive Engineer (EE) of AMC → City Engineer → Municipal Commissioner

**Human resource involved**

**Role of Private Operator**

- The STP is constructed and operated by a private operator under a DBOT contract.
- Commissioned in 2019, the plant will be operated privately for five years as per the agreement.
- The capital cost of the plant has been fully paid by the ULB.
- The private operator raises monthly invoices, which are paid by the ULB.
- Only about 20% of the plant's electricity demand is met through gas-based power generation. The remaining electricity cost is borne by the city.
- The absence of a SCADA system limits real-time monitoring and makes performance improvement difficult. The operator cannot accurately monitor gas production or electricity generated from it.
- Oversight is limited as the contract does not include clauses or penalties on sludge management or electricity generation.



**STP Power Requirement**

**Approx 15,000- 20,000 Unit/Day**



**Power Generation From Biogas**



**MAX 3000-5000 Unit/day**  
~20% electricity requirement is met by the electricity generated from gas



**~80% provided** by Maharashtra state electricity board

**Penalties on**

- Effluent standards – 5% of the raised bill will be deducted if standards not met by Pvt Operator
- No penalty on Biogas generation

# Summary: Skilled human resource and performance-linked contracts are essential to drive methane recovery outcomes

- Operational performance varies significantly across cities and is closely linked to operator capacity and contractual structures. Even well-designed plants underperform without skilled operators and strong accountability mechanisms.
- From the actual cases, it is identified that the STPs designed based on wastewater quality, proper backward linkages, and a monitoring system with skilled staff (like the case of Jaipur) can generate more methane
- Improving sludge handling, reducing methane leakages, and upgrading gas engines can substantially increase methane production and improve electricity-generation efficiency.
- For effective methane-based resource recovery, cities must ensure strong alignment between STP design and operations—particularly maintaining good influent quality, reliable sludge management, skilled staffing, and efficient gas-to-power systems.

## Supporting Observations:

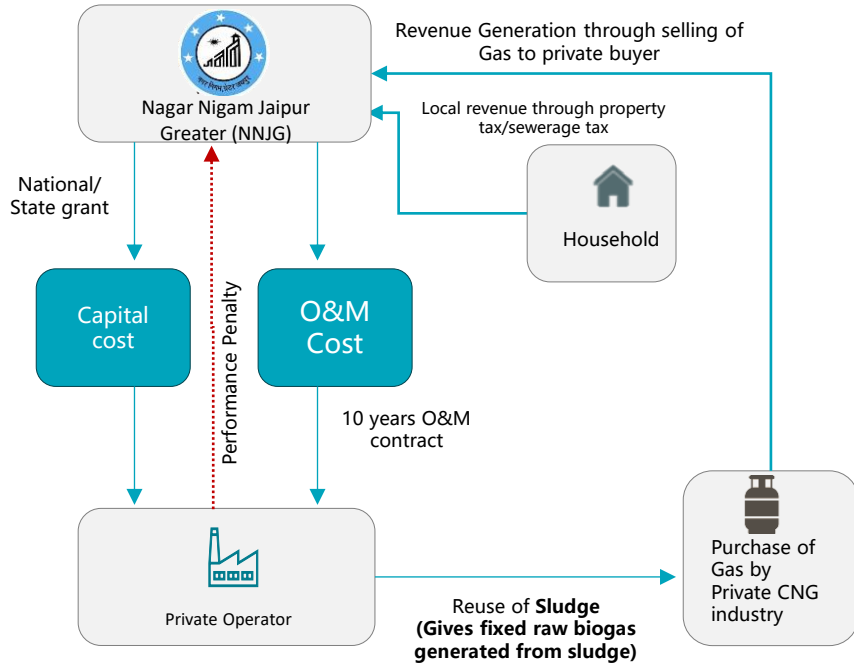
- Skilled operators better manage shock loads and sludge systems, improving methane yield.
- Variations in private operator involvement affect consistency across cities.
- Contracts focus mainly on effluent compliance, with limited incentives for methane recovery.

### 3. Business and financial models

Business models were analysed to assess the financial viability of methane recovery systems, including revenue generation opportunities, cost recovery mechanisms, market linkages, and resource recovery pathways.



# Business and Financial Model of Jaipur- Delawas STP



## JNN Model Description:

ULB awarded a DBOT contract to private operator with 10 years of O&M contract. ULB pays monthly fees to private operators as an O&M fees and if the private operators fails to generate quoted gas and uses additional electricity, penalty is levied by the ULB .It's a performance linked contract



## Funding and Financing

### Expenditure under Opex

#### Operations and maintenance of STPs

1. Maintenance of STP units and premises
2. Human resources: 59% Operation cost on salaries
3. Electricity cost

### Revenue Stream for ULB:

#### Recovers 44% of the O&M cost through selling of gas Direct

1. **Selling of Gas to nearby Private gas buyer-** Private CNG company buy 6500 m<sup>3</sup>/day raw biogas from ULB at 6.5 Rs/m<sup>3</sup>.
2. **Through penalty** – ULB gives fixed units of electricity a day- In case of less electricity generation at plant, private operator takes additional electricity from the Grid and pays 10 Rs/Unit to ULB as a penalty

#### Indirect

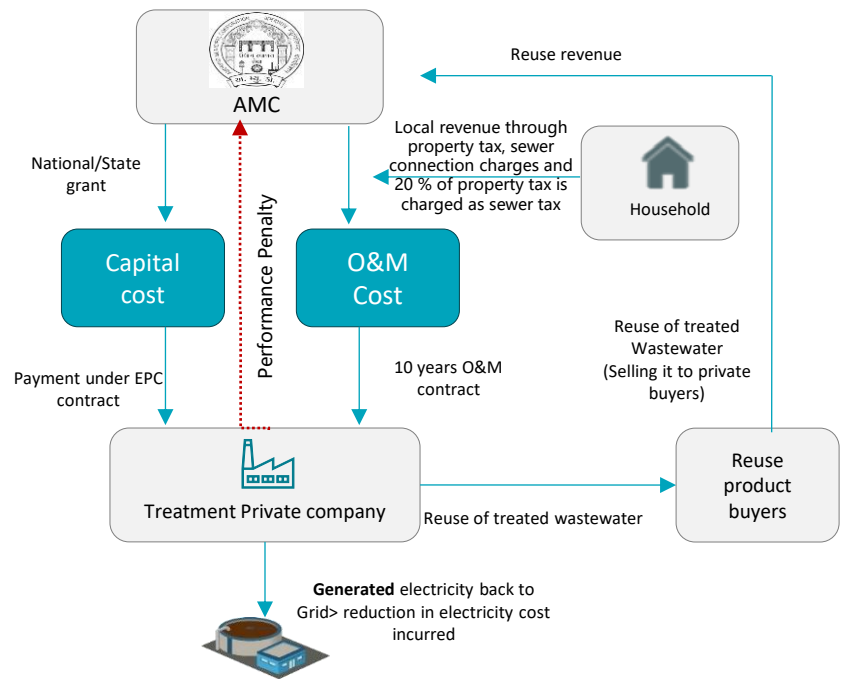
1. **Saving on electricity requirement** through electricity generation at Plant from Biogas (**Indirect revenue**)



## Risk Mitigation- Operational risk mitigation through Performance Penalty Clauses:

1. **Biogas Supply Shortfall Penalty Clause:** The STP contractor shall supply 6,500 Nm<sup>3</sup> of biogas per day to the gas buyer company.
  - In case of any shortfall in the daily committed supply, the contractor shall pay a penalty of **₹6.5 per m<sup>3</sup> of gas not supplied, to the Urban Local Body (ULB).**
2. **Electricity Shortfall Penalty Clause:** The total electricity requirement of STP is approximately 26,000–27,000 units per day. The Urban Local Body (ULB) shall provide 17,415 units per day free of cost. The remaining electricity requirement shall be met through power generation from biogas and solar energy at the STP.
  - If the electricity generated at the plant is insufficient, the private operator may draw the shortfall from the ULB grid. However, for every additional unit drawn beyond the 17,000 units provided, the private operator shall pay a penalty of **₹8.5 per unit to the ULB.**

# Business and Financial Model of Ahmedabad- Pirana STP



**AMC Model Description:**  
 ULB awarded EPC contract to private operator with 10 years of O&M contract. ULB pays monthly fees to private operators as an O&M fees and if the private operators fails to generate quoted electricity, penalty is levied by the ULB.



## Funding and Financing

### Expenditure under Opex

#### Operations and maintenance of STPs

1. Maintenance of STP units and premises
2. Human resources:
3. Electricity cost

### Revenue

#### Direct revenue

#### Stream for ULB:

#### 1. Selling of treated wastewater to nearby Private Company:

AMC sell 3MLD treated wastewater to private company at the rate of **5 Rs/KLD**- Reused at waste to energy plant as a coolant

#### Indirect Revenue

#### 1. Biogas Utilization & Power Savings:

~40% electricity required to run the STP is met through electricity generated from biogas at STP. 8,000 kWh/day electricity from 4000-6500 m<sup>3</sup>/day biogas used to run STP.

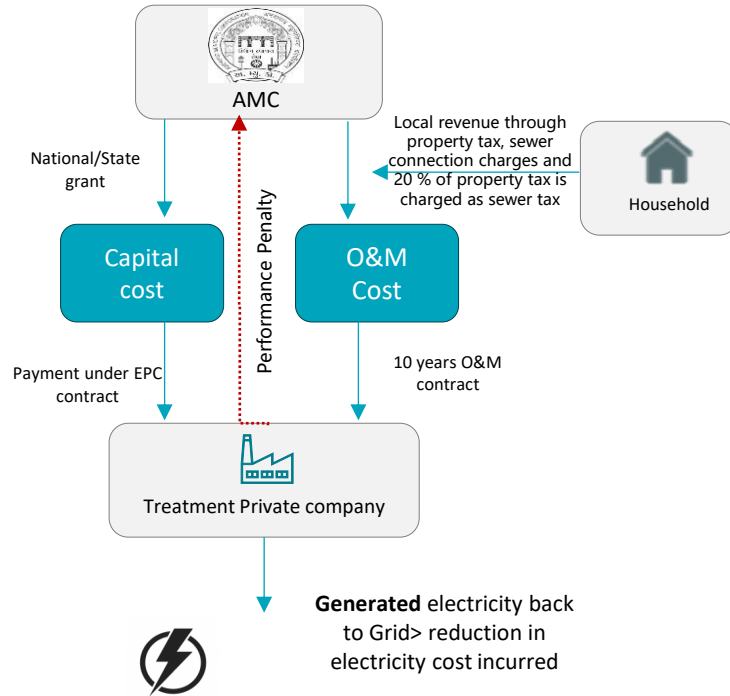


## Risk Mitigation- Operational risk mitigation through Performance

### Penalty Clauses:

- **Electricity Shortfall Penalty Clause:** In case of less biogas or electricity generation at plant, AMC imposes penalties.

# Business and Financial Model of Ahmedabad- Vinzol STP



## AMC Model Description:

ULB awarded EPC contract to private operator with 10 years of O&M contract. ULB pays monthly fees to private operators as an O&M fees and if the private operators fails to generate quoted electricity, penalty is levied by the ULB.



## Funding and Financing

### Expenditure under Opex

#### Operations and maintenance of STPs

1. Maintenance of STP units and premises
2. Human resources:
3. Electricity cost

### Revenue

#### Indirect Revenue

### Stream for

#### Biogas Utilization & Power Savings:

### ULB:

~30% electricity required to run the STP is met through electricity generated from biogas at STP. 4,000-6,000 kWh/day electricity from 2,500-3,500 m<sup>3</sup>/day biogas used to run STP.

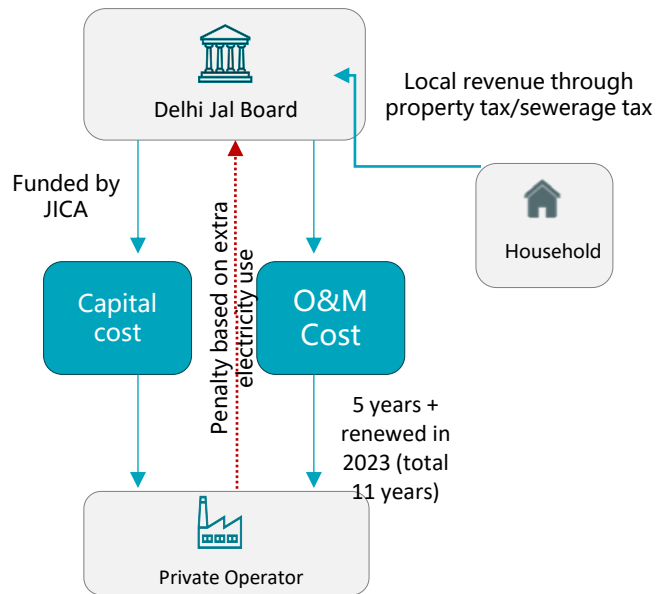


### Risk Mitigation- Operational risk mitigation through Performance

#### Penalty Clauses:

- **Electricity Shortfall Penalty Clause:** In case of less biogas or electricity generation at plant, AMC imposes penalties.

# Business and Financial Model of Delhi- Okhla STP



## DMC Model Description:

ULB awarded the DBOT contract to a private operator with 5 years of O&M contract, which was extended to another 11 years in 2022. ULB pays monthly fees to private operators as O&M fees, and if the private operators fail to generate the quoted electricity, a penalty is levied by the ULB.



## Funding and Financing

### Expenditure under Opex

- **Operations and maintenance of STPs**
- **Human Resources:** Salaries of plant operators, engineers, and support staff.
- **Electricity Charges:** Grid power consumption, including peak-hour tariffs and penalties (if any).

### Revenue Stream for ULB:

#### Direct

1. **No revenue from biogas** – Biogas generation is very low (only ~30% of total electricity requirement)
2. **No electricity generation or sale mechanism** – 70% electricity is drawn from the grid

#### Indirect

1. **Savings** on electricity through use electricity generated from biogas for internal operations of STP
2. **Avoided sludge disposal cost** – Dried sludge is given free to farmers

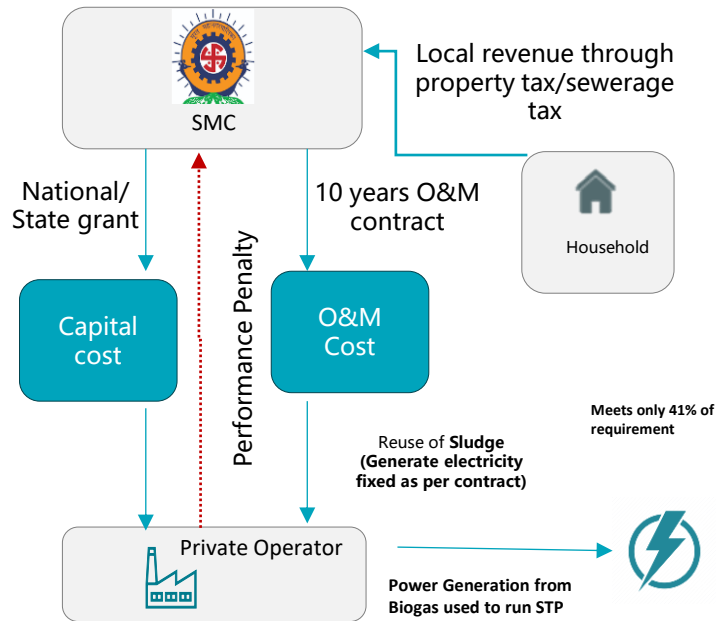


## Risk Mitigation- Operational risk mitigation through Performance

### Penalty Clauses:

1. **Electricity Consumption Clause:**  
Penalty of ₹10–12 per kWh if grid power consumption exceeds the permitted limit (peak/lean hour basis).
2. **Defined O&M Cost Structure:**  
O&M cost (approx. ₹87 lakh/month for 136.4 MLD plant) is contractually fixed, placing responsibility on the operator to manage maintenance, human resource, and energy efficiently within the agreed cost framework.
3. **Performance & Compliance Monitoring:**  
Operator accountable for maintaining treatment efficiency and meeting discharge standards; non-performance may lead to contractual deductions or penalties.

# Business and Financial Model of Surat- Anjana STP



## SMC Model Description:

ULB awarded **EPC contract** to private operator with 10 years of O&M contract. ULB pays monthly fees to private operators as an O&M fees and if the private operators fails to generate quoted gas then penalty is levied on private STP operator, additional repair and maintenance cost is on ULB based on the bill raised by the private operator.

## Funding and Financing

### Expenditure under Opex

#### Operations and maintenance of STPs

1. Maintenance of STP units and premises
2. Human resources
3. Electricity cost

### Revenue Stream for ULB:

#### Direct

1. **Through penalty** – ULB gives fixed units of electricity a year- In case of less electricity generation at plant, private operator are penalized by the ULB

#### Indirect

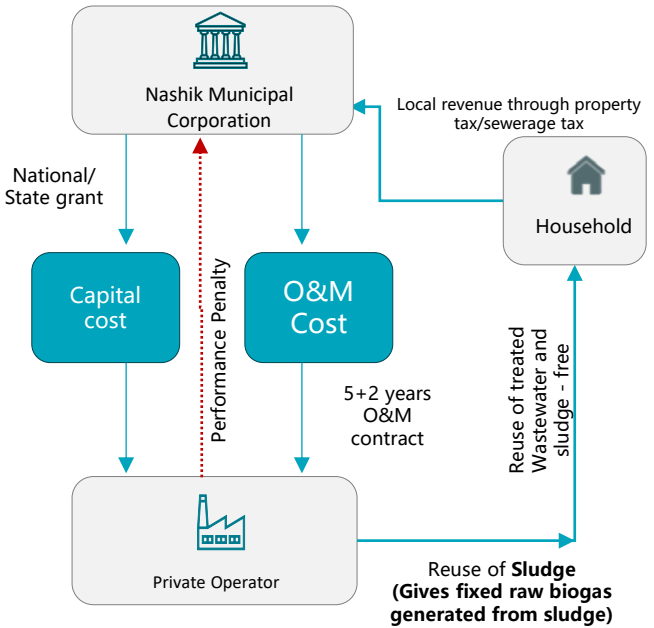
1. **Saving on electricity requirement** through electricity generation at Plant from Biogas (**Indirect revenue**)



## Risk Mitigation- Operational risk mitigation through Performance Penalty Clauses:

- **Penalty on Biogas Power: Minimum Hours, Electricity generation:** The biogas power plant is expected to run at least 5,400 hours per year. In the same year, it is also expected to generate at least 2,700,000 kWh of electricity. If the plant runs for less than 5,400 hours/year, or generates less than 2,700,000 kWh/year, a penalty will be charged.
- **Penalty rates :** The authority will calculate both shortfalls (hours and kWh) and apply the higher penalty amount (“whichever is higher”).
  - Rs. 500 per hour of non-operation (below 5,400 hours), and/or
  - **Rs. 4 per kWh for the shortfall in energy generation (below 2,700,000 kWh).**
- **During the 10-year O&M period, there may be one major scheduled maintenance year (as per manufacturer’s recommendation). In that one year:** The minimum requirement is relaxed to 4,860 hours (90% of 5,400 hours), and 2,430,000 kWh (90% of 2,700,000 kWh). **This relaxation is allowed only once in the 10-year O&M period.**

# Business and Financial Model of Nashik- Tapovan STP



## NMC Model Description:

ULB awarded the DBOT contract to a private operator with 5 years of O&M contract that was extended for another two years. ULB pays monthly fees to private operators as O&M fees. There are no penalty clauses related to biogas generation or electricity output due to the absence of a SCADA-based monitoring system

## Funding and Financing

### Expenditure under Opex

#### Operations and maintenance of STPs

1. Maintenance of STP units and premises
2. Human resources: Operation cost on salaries
3. Electricity cost

### Revenue Stream for ULB:

#### Direct

1. **No revenue from biogas** – Biogas generation is very low (only ~5% of total electricity requirement) and not utilized or sold.
2. **No electricity generation or sale mechanism** – Entire electricity is drawn from the grid; no revenue or penalty clause linked to energy.

#### Indirect

1. **Minimal savings** through limited use of biogas for internal operations
2. **Avoided sludge disposal cost** – Dried sludge is given free to farmers



## Risk Mitigation- Operational risk mitigation through Performance Penalty Clauses:

### 1. Treated Sewage Quality Clause:

Penalty for not meeting MPCB norms:

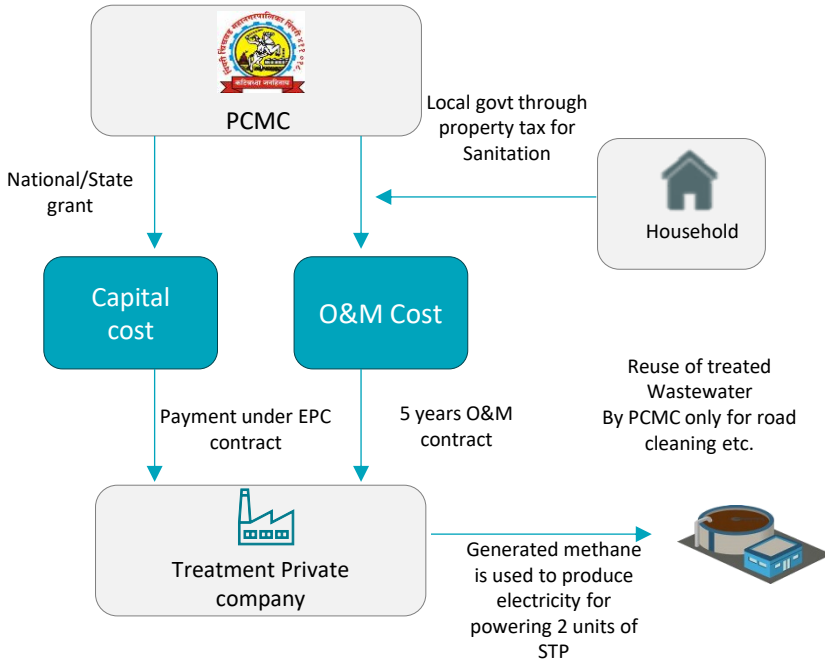
- Up to 2 times/month – Nil
- 2–5 times – ₹5,000/occurrence
- 5–10 times – ₹10,000/occurrence
- Above 10 – ₹20,000/occurrence or contract action

### 2. O&M Performance Clause:

- Penalties for **non-desilting, sludge bypass, poor cleaning, or delayed data recording**– ₹500–₹2,000/day

- **Staff absenteeism:** ₹800–₹1,000/day
- **Missing reports or safety gear:** ₹5,000–₹10,000/occurrence
- **Power factor penalty** deducted from contractor bill
- 3. Biogas & Energy Clause:**
  - No clause for **biogas or power generation**, as biogas meets only ~5% of total energy needs.
  - Entire power drawn from grid; **no generation-linked penalty or incentive.**

# Business and Financial model of Akurdi STP



## PCMC Model Description:

ULB awarded a DBOT contract to a private operator with 5 years of O&M contract. ULB pays monthly fees to private operators as O&M fees. There are no penalty clauses related to biogas generation or electricity output due to the absence of a SCADA-based monitoring system



## Funding and Financing

**Expenditure under Opex**

**Operations and maintenance of STPs**

1. Maintenance of STP units and premises
3. Electricity cost

**Revenue Stream for ULB:**

**No direct revenue generated**

**Indirect**

Indirect revenue via energy cost savings through biogas-based in-house power generation.



**Risk Mitigation- Operational risk mitigation through Performance Penalty Clauses:**

1. Effluent standards not maintained: **5% penalty on monthly O&M cost** (performance penalty clause)
2. Low biogas generation (due to COD): Regular influent monitoring; explore co-digestion possibilities
3. Manual operation due to SCADA failure: SCADA repair or upgrade cost to be included under OPEX

# Summary: Financial sustainability requires both efficient systems and strong reuse markets.

- Methane recovery alone does not ensure financial viability. Revenue generation depends on efficient energy conversion systems and the availability of reuse pathways.
- In old STPs like Nashik where biogas generation was not part of the penalty clauses and not seen as a resource, the Methane Equivalent to COD converted under anaerobic condition reduced to 0.1.

## Supporting Observations:

- Electricity generation depends on methane yield and engine efficiency (Jaipur, Ahmedabad, Delhi).
- High methane potential is underutilised due to leakages and outdated engines (Surat, Nashik).
- Revenue is mostly limited to internal electricity use, with few external markets (Jaipur exception).
- Efficient gas to energy engine systems (Delhi) improve energy recovery even at lower methane yield.
- Resource recovery from sludge and wastewater helps STPs to recover operational costs.
- STPs have many environmental benefits; considering the economic benefits of these makes the STPs economically viable.



## 4. Monitoring and Performance Evaluation- Identified opportunities and challenges

Monitoring systems and plant performance were evaluated to understand the affecting factors behind methane recovery, identify operational constraints, and highlight opportunities for improving methane utilisation and energy recovery.

# Monitoring and Performance Evaluation of Jaipur - Delawas STP(1/2)



## Monitoring/ performance evaluation:

- Operations monitored via **SCADA**
- **Highly skilled operators and labours**



## Effluent Quality

### Inlet:

- pH: 6
- BOD: 280 mg/l
- COD: 700 mg/l
- TSS: 550 mg/l
- Total Nitrogen < 57 mg/l
- Total phosphorus: <2 mg/l

### Outlet

- pH: 6.5- 8.5
- BOD: <= 10 mg/l;
- COD: <= 50 mg/l
- TSS: < 20 mg/l
- Total Nitrogen < 20 mg/l
- Total phosphorus: <1 mg/l

**The performance of the STP has been influenced by the presence of SCADA-based monitoring and a skilled operations team, which helped maintain consistent effluent quality across key parameters such as BOD, COD, TSS.**



## Challenges:

**Few challenges that hinder the plant's ability to achieve optimal methane generation, stable electricity output, and overall operational efficiency are as below:**

- The STP faces **silting and high nitrogen issues**, which affect both the treatment efficiency and the quality of sludge entering the digestion process. **Silting** reduces hydraulic capacity in tanks and channels, disrupts flow patterns, and increases maintenance needs. **High nitrogen levels** can interfere with biological treatment and may also influence the stability of downstream processes.
- **High O&M and electricity costs** continue to be a major challenge, especially when the plant operates below full capacity. Lower utilisation leads to higher unit costs, and any drop in methane generation directly increases dependence on grid electricity, further raising expenses.
- **Less efficiency in electricity generation** is due to multiple factors, including methane leakages, gas engine losses, fluctuating gas quality, and inconsistencies in gas supply. Engine efficiency is also affected by wear and tear, lack of timely servicing, or suboptimal loading conditions.

# Monitoring and Performance Evaluation of Jaipur - Delawas STP(1/2)



## Operational advantages

- **Silting issue** has been resolved by adding one component at the start of the primary treatment units. Better flow conditions also support smoother treatment and more consistent sludge characteristics for methane generation.
- Substantial portion of its electricity needs is met through in-house power generation from methane and solar plant. By generating an internally, the plant can reduce dependence on grid power, lowering overall O&M expenditure and improving financial sustainability.
- Promotes resource recovery and partial energy self-sufficiency
- A strong forward linkage with the gas buyer ensures that all generated methane is productively utilized with no flaring. The presence of a ready market for raw biogas improves the reliability of revenue streams and encourages operators to maintain stable gas production. This alignment between production and demand reduces wastage and supports long-term sustainability of the STP's energy recovery system.



## Identified Opportunity

- Sludge from secondary clarifier is not added to the Anaerobic digester. Using sludge from the secondary treatment unit, which contains higher organic content and can significantly enhance methane generation. This would in turn increase electricity production and reduce dependency on external power sources.
- The efficiency will increase while the STP utilisation will become 100% , as higher inflow volumes lead to more consistent sludge generation and improved digester performance. Full-capacity operation also helps distribute fixed O&M costs more efficiently.
- The plant currently generates less methane than expected, and one potential approach to increase gas yield is the addition of co-substrates such as Napier grass. Such co-digestion strategies are widely recognized for boosting methane production in wastewater settings.
- Methane loss due to leakages directly impacts electricity output, engine performance, and revenue potential. Addressing these leakages would allow the plant to achieve expected standards.

# Monitoring and Performance Evaluation of Ahmedabad- Pirana STP



## Monitoring/ performance evaluation:

- The performance of the STP has been influenced by the presence of SCADA-based monitoring and a skilled operations team, which helped maintain consistent effluent quality across key parameters such as BOD, COD, TSS.



## Effluent Quality

### Inlet:

- pH: 6
- BOD: 180-250 mg/l
- COD: 250-350 mg/l
- TSS: 200-300 mg/l

### Outlet

- pH: 6.5- 8.5
- BOD:  $\leq 10$  mg/l;
- COD:  $\leq 50$  mg/l
- TSS:  $\leq 10$  mg/l



## Identified Opportunity

- If input wastewater quality is improved, then COD values is increased that lead to more biogas generation
- High pumping capacity from primary treatment unit can increase sludge value input and more gas generation
- Less methane generation- not as per standard so if with the help of external ingredients like Nappier Grass if STP generates more methane
- Not generating electricity as per standards due to leakages- If leakages are reduced, then can generate more energy as per standards



## Challenges:

- **Seasonal Variation** in Total Suspended Solids
- **Seasonal temperature** variation affecting gas generation
- **Shock loads affect operational efficiency and affect the biogas generation**
- **High O&M and electricity costs:** Operating costs remain high due to labor-intensive processes and frequent dependence on grid electricity, especially when methane production is inconsistent.
- **Fully automated O&M:** Fully automated AI/ML-based sludge cycle management is required for process optimization
- **Less efficiency in electricity generation:** Electricity generation efficiency is reduced due to fluctuating gas quality, engine losses, and inconsistent digester performance.



## Operational advantages

- Significant energy cost savings through in-house power generation
- Promotes resource recovery and partial energy self-sufficiency

# Monitoring and Performance Evaluation of Ahmedabad- Vinzol STP (1/2)



## Monitoring/ performance evaluation:

- The performance of the STP has been positively influenced by the presence of SCADA-based monitoring systems and a skilled operations team, enabling consistent compliance with effluent quality standards across key parameters such as BOD, COD, and TSS.
- In 2023, the Central Pollution Control Board (CPCB) constituted a task force to monitor wastewater inflow quality. This intervention has reduced helped minimizing operational shocks and improving treatment stability for a year.



## Effluent Quality

### Inlet:

- pH: 4.7
- BOD: 50-90 mg/l
- COD: 250-320 mg/l
- TSS: 100-300 mg/l

### Outlet

- pH: 7.16
- BOD:  $\leq 10$  mg/l;
- COD:  $\leq 50$  mg/l
- TSS:  $\leq 10$  mg/l



## Operational advantages

- **Energy Performance:** The plant demonstrates strong energy recovery performance, with electricity generation meeting a significant share of total energy demand (~30%), **despite suboptimal influent quality.**
- **Operational Stability:** Improved influent monitoring and advanced process control systems have enhanced process stability, reducing fluctuations in treatment efficiency.
- **Sludge and By-product Management:** Efficiency in sludge handling, digestion, and potential reuse (if applicable) can be included as a key performance indicator.
- **Responsiveness to Shock Loads:** The plant's ability to withstand and recover from shock loads (due to industrial discharge variability) is an important indicator of resilience.
- **Preventive and Predictive Maintenance:** Use of SCADA and operational data for predictive maintenance can be highlighted if applicable.
- **Institutional and Contractual Framework:** Performance-linked O&M structures or contractual provisions (like penalties/incentives) can also influence operational efficiency.

# Monitoring and Performance Evaluation of Ahmedabad- Vinzol STP (2/2)



## Identified Opportunity

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- **Advanced technology enables shock load resilience:** High-tech systems allow the plant to continue functioning despite frequent acidic inflows—this resilience can serve as a model for other high-variability urban STPs.
- **Scope for stricter industrial regulation and pre-treatment enforcement:** Existing challenges highlight the need for stronger upstream control, which can significantly improve influent quality and plant performance.
- **Data-driven optimization of operations:** Frequent shocks provide real-time learning opportunities to improve process control, automation, and adaptive treatment strategies.
- **Potential for enhanced biogas generation:** Improving influent COD through industrial regulation or co-digestion strategies could significantly increase methane production and energy self-sufficiency.
- **Demonstration of resilient infrastructure under stress conditions:** Vinzol STP can be positioned as a case study for designing and operating treatment plants in challenging urban-industrial contexts.



## Challenges:

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- **Seasonal Variation** in Total Suspended Solids
- **Seasonal temperature** variation affecting gas generation
- **Shock loads affect operational efficiency and affect the biogas generation**
- **High O&M and electricity costs:** Operating costs remain high due to labor-intensive processes and frequent dependence on grid electricity, especially when methane production is inconsistent.
- **Fully automated O&M:** Fully automated AI/ML-based sludge cycle management is required for process optimization
- **Less efficiency in electricity generation:** Electricity generation efficiency is reduced due to fluctuating gas quality, engine losses, and inconsistent digester performance

# Monitoring and Performance Evaluation of Delhi- Okhla STP



## Monitoring/ performance evaluation:

- **SCADA System:** Real-time monitoring of flow, process units
- SOP maintained by private operator to run the plant efficiently and to avoid big O&M that incurred by not following the SOP of efficient O&M of STP
- Continuous tracking of effluent parameters (BOD, COD, TSS, pH).
- **Periodic Review:** Regular reporting and performance evaluation under DBOT contract.



## Effluent Quality

### Inlet:

- BOD: 140-150 mg/l
- COD: 250-300 mg/l
- TSS: 200-250 mg/l

### Outlet

- BOD: 6-10 mg/l;
- COD: 25- 35mg/l
- TSS: 5-10mg/l

- MLSS (Aeration Tank): ~3,000–4,000 mg/L (maintained for ASP process)



## Challenges:

- **High Energy Dependence:** Major electricity requirement (11,000–15,000 kWh/day) is met from the grid, increasing operational costs.
- **Underutilization of Capacity:** Plants operating at ~50% capacity, affecting overall efficiency and optimal asset utilization.



## Benefits

- **Resource Recovery & Reuse:** Treated wastewater reused for horticulture/landscaping and sludge provided to farmers, promoting circular economy.
- Biogas is utilized for on-site electricity generation (4,000–5,000 kWh/day), reducing partial dependence on grid power and promoting sustainable operations.



## Identified Opportunity

- **Old Experience of selling biogas to residents and industries :** In 2002, DJB used to sell biogas to residents. However, due to O&M issues, the increasing use of LPG, reduction in gas generation, and declining demand, the city stopped supplying biogas to users. This experience can still be useful under the SATAT scheme, where biogas can be sold to oil companies.
- **Generate revenue from selling of treated wastewater :** Develop structured reuse agreements with industries, the construction sector, agriculture, and urban utilities to generate revenue from treated wastewater and dried sludge.
- **Exploring schemes like SATAT:** The city can explore schemes such as SATAT to sell raw biogas to oil companies. The city is currently in discussion with oil companies, which presents a good opportunity.
- **Presence of technically sound Private operator:** Despite being one of the oldest plants in Delhi, this STP is well maintained by a hired private operator. The operator has trained staff and follows standard SOPs for operating and maintaining the plant.
- **Need to explore ways to generate revenue from biogas:** Considering the presence of a strong oil market in Delhi, STPs generating biogas should explore selling it to the private market, as this may be more beneficial than generating electricity solely for internal use at the STP.

# Monitoring and Performance Evaluation of Surat - Anjana STP



## Monitoring/ performance evaluation:

- Operations monitored via **SCADA**
- **Highly skilled operators and labours**



## Inlet Effluent Quality parameters:

### Inlet:

- pH: 6.5-9.5
- BOD: 250-300 mg/l
- COD: 500-650 mg/l
- TSS: 300-375 mg/l

### Outlet

- pH: 5.5-9
- BOD  $\leq 10$  mg/l;
- COD  $< 50$  mg/l
- TSS  $< 20$  mg/l



## Operational Advantages

- Energy cost savings through in-house power generation.
- Promotes resource recovery and partial energy self-sufficiency



## Identified Opportunity

- Not generating electricity as per standards due to leakages-If leakages are reduced then can generate more energy as per standards



## Challenges:

- Oldest plant of Surat and has high operational and maintenance-related issues; due to this, the plant is unable to meet the treatment water quality standards of BOD and TSS as per the GPCB norms.
- High O&M and electricity costs
- Less efficiency in electricity generation
- Required highly skilled staff for operation and maintenance
- The plant, commissioned in 2003, initially generated sufficient methane to meet its electricity demand; however, methane production has declined over time due to technical inefficiencies.
- After 22 years of operation, both O&M costs and electricity requirements have increased, while methane generation has dropped to around 40% of the designed capacity.
- With the STP nearing the end of its 25-year lifecycle, SMC is planning to renovate the plant and is exploring options to enhance methane generation and expand reuse pathways and utilise the gas for revenue-generating uses such as cooking fuel and CNG.

# Monitoring and Performance Evaluation of PCMC - Akurdi STP



## Monitoring/ performance evaluation:

Highly skilled operators and labours



## Effluent Quality:

### Inlet:

- pH: 6.9
- BOD: 130 mg/l
- COD: 250-350 mg/l
- TSS: 149 mg/l

### Outlet

- pH: 6.5- 8.5
- BOD: <= 10 mg/l;
- COD: <= 20 mg/l
- TSS: <= 10 mg/l



## Operational advantages

- Small footprint with PLC-based automation and compact design integrating primary clarification, anaerobic digestion, and gas storage in the Combitreat unit
- Pimpri-Chinchwad's Combitreat STP, PLC automation ensures compact, energy-efficient operation by coordinating biogas production, sequencing batch reactors, and energy recovery without manual intervention, reducing downtime and optimizing sludge handling
- Significant **energy cost savings** through in-house power generation
- Promotes **resource recovery** and partial energy self-sufficiency



## Challenges:

- **Low COD in influent:** Low COD levels in the incoming sewage reduce the organic load available for digestion, resulting in lower methane generation
- **SCADA non-functional:** The non-functional SCADA system forces operators to run the plant manually, limiting process control and operational efficiency.
- **No real-time methane monitoring:** The absence of a real-time methane monitoring system restricts the ability to track gas production accurately and respond to fluctuations promptly.
- **Limited wastewater reuse:** Treated wastewater is currently reused only for road cleaning and gardening within the STP, leaving broader reuse potential unutilised.
- **Sludge reuse not explored:** Sludge reuse options have not yet been developed or implemented, resulting in missed opportunities for resource recovery.



## Identified Opportunity

- If input wastewater quality is improved, then COD values is increased that lead to more biogas generation
- High pumping capacity from primary treatment unit can increase sludge value input and more gas generation
- Less methane generation- not as per standard so if with the help of external ingredients like Nappier Grass if STP generates more methane
- Not generating electricity as per standards due to leakages-If leakages are reduced, then can generate more energy as per standards

# Monitoring and Performance Evaluation of Nashik - Tapovan STP



## Monitoring/ performance evaluation:

- **No SCADA or automation system** – operations and data recording done manually.
- **Dependence on on-site staff** for process monitoring, maintenance, and lab testing.



## Effluent Quality

### Inlet:

- pH: 6
- BOD: 100–120 mg/l
- COD: 300–320 mg/l
- TSS: 140–150 mg/l
- MLSS: 50,000–60,000 mg/l

### Outlet

- pH: 6.5- 8.5
- BOD: 15-20 mg/l;
- COD: 55-65 mg/l
- TSS: 20-30 mg/l
- MLSS: 50,000–60,000 mg/l



## Operational advantages

- Continuous operation with 100% utilization of both STP units.
- Stable effluent quality meeting discharge norms.
- Sludge reused by farmers, reducing disposal costs.



## Identified Opportunity

- **Potential to enhance biogas generation** by improving digester performance and reducing gas leakages.
- **Opportunity to utilize sludge** effectively for co-digestion and higher methane yield.
- **Scope for introducing SCADA** and automation to optimize operations and reduce manual errors.



## Challenges:

- **High operational and maintenance issues** due to aging infrastructure.
- **High leakage of biogas:** The gas generated at UASB is leaked in the process. A significant proportion of the biogas generated at the UASB unit is lost due to leakages, and the aged gas engine further limits conversion efficiency, resulting in electricity generation meeting only about 5% of the STP's total power demand.
- **No SCADA or automation**, leading to manual monitoring and inefficiencies
- **Biogas dome material:** Here, the gas holding tank has MS dome, which is the major reason behind high leakage compared to other STPs with a floating gas holder dome.
- **Monitoring Biogas generation** was not part of the contractual agreement, as there was no penalty clause led to ignorance of the gas generation system.
- Despite having complete anaerobic treatment technology like UASB-based, methane generation is significantly lower at such STPs than in STPs with aerobic treatment technology systems(SBR, IFAS).
- Major reason behind this is the absence of a monitoring system, at the end-of-life cycle of STP, unskilled Labour, and no incentives or penalties focusing on biogas generation and using methane as a resource. There was no clause on generating electricity and using it to run STP.

# Summary: Operational efficiency and accountability drive actual biogas generation more than technology selection alone

- Biogas generation trends further highlight these differences. Jaipur records the highest biogas generation due to good wastewater quality and high COD levels. However, Surat, despite having high COD, shows lower biogas generation due to significant methane leakage, particularly from digester units.
- Monitoring gaps are a key issue across most plants. Limited use of real-time monitoring systems and a lack of data visibility restrict the ability to optimise performance.
- Additionally, poor sludge management and inconsistent influent quality further impact digestion efficiency and methane production. At the same time, clear opportunities emerge.
- Data-driven monitoring is essential to bridge the gap between potential and actual methane recovery.
- Adoption of improved gas-holder systems, high-efficiency engines, real-time monitoring tools such as SCADA, and better sludge management practices can significantly enhance methane recovery and energy generation

# Contents

- 1 Overview- Need and Study approach
- 2 Documentation of existing methane capture and reuse practice
- 3 Key findings and learning –  
*Affecting factors, Challenges, Opportunities*  
Way forward

# Technical factors affecting methane recovery

Methane recovery depends on sludge digestion, gas containment, engine efficiency, and plant design rather than treatment technology alone.

## ***Sludge Digestion System:***

- Sludge digestion efficiency drives methane generation (Jaipur, Ahmedabad).
- Inefficient sludge pumping disrupts digestion processes.
- Poor sludge quality reduces biogas yield.
- Co-digestion can improve methane generation potential.

## ***Influent Quality and Plant Configuration***

- Stable influent quality supports methane generation.
- VFD pumps, automation, and upgraded equipment improve operational performance.
- Newer systems better withstand shock loads and variable wastewater quality.

## ***Gas Holder Design:***

- Gas holder type directly affects methane leakage.
- Balloon-type gas holders (Jaipur, Ahmedabad) show lower methane losses than RCC gas holders (Delhi, Nashik, Surat).

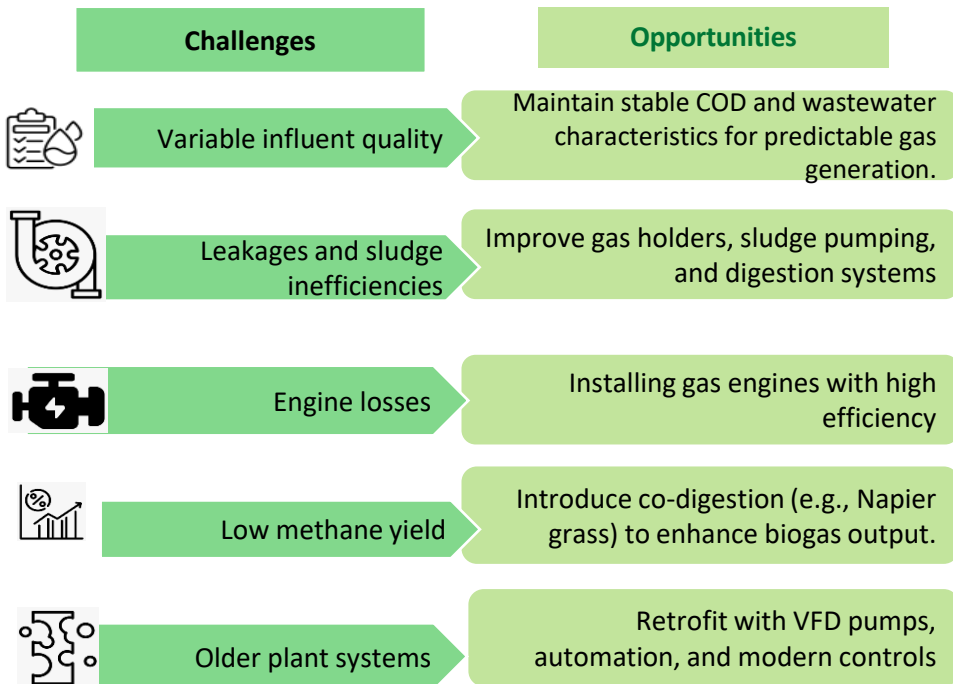
## ***Engine Efficiency:***

- Electricity generation depends on engine efficiency.
- Older generators result in lower energy conversion efficiency.

- Methane recovery depends on stable influent quality, efficient sludge digestion, and minimizing methane leakages throughout the treatment process.
- Gas holder design significantly influences methane capture efficiency. Balloon-type gas holders demonstrate lower methane losses compared to RCC-based systems.
- High-efficiency engines and modern equipment, such as VFD pumps, improve energy conversion efficiency and reduce operational losses.
- Co-digestion using supplementary feedstocks such as Napier grass can increase methane yield; however, maintaining digester health, bacterial culture, sludge characteristics, and MLSS levels remains critical for stable operation.
- Technology upgrades should improve methane recovery while ensuring compliance with wastewater effluent quality standards

# Technical optimisation offers one of the fastest pathways for improving methane recovery and resource utilisation at STPs.

## Converting Technical Challenges into Opportunities..



- The assessment indicates that many technical barriers to methane recovery can be addressed through targeted improvements in plant design, equipment, and operational systems.
- Improving sludge digestion efficiency, reducing methane leakage, and upgrading energy conversion systems can significantly increase methane recovery and electricity generation.
- While co-digestion offers an opportunity to improve methane yield, its success depends on maintaining digester stability, sludge quality, bacterial culture, and MLSS levels.
- Technology upgrades should therefore focus on improving methane recovery while ensuring compliance with wastewater treatment standards.

# Operational factors affecting methane recovery

Operational excellence is often more important than technology in determining actual methane recovery outcomes.

## *Operator Capacity*

- Skilled operators directly influence methane recovery performance.
- Managing digesters, sludge systems, and CHP units requires specialised expertise.

## *Private Operator Experience*

- Plants operated by experienced operators demonstrate better outcomes.
- Performance varies significantly based on operator capability.

## *O&M Practices*

- Sludge pumping frequency affects methane generation.
- Preventive maintenance improves recovery efficiency.
- Gas system maintenance reduces methane losses.

## *ULB Capacity Constraints*

- ULB staff often lack specialized expertise in anaerobic digestion systems.
- Conventional capacity-building programmes alone are often insufficient.

- Effective management of shock loads, sludge pumping, and digestion efficiency directly influences methane generation and electricity production.
- Methane recovery systems require specialised operational expertise beyond conventional wastewater treatment operations.
- ULB officials highlighted that anaerobic digesters, gas systems, and electricity generation units require dedicated technical knowledge often unavailable within municipal teams.
- Digester performance depends on continuous management of sludge characteristics, bacterial activity, feed rates, and operational parameters.
- Co-digestion can improve methane yield but requires additional infrastructure such as storage facilities, shredders, crushers, and feed handling systems, increasing O&M costs
- Capacity-building programmes alone are often insufficient; successful facilities rely on experienced operators and dedicated O&M teams.

# Specialised operational capacity is essential for converting methane recovery potential into actual performance.

## Challenges

## Opportunities



Inexperienced operators

Engage experienced STP operators



Shock load management

Automation and operational controls.



Poor sludge management

Improved sludge handling systems



Weak O&M practices

Standard operating procedures



Limited availability of skilled operators for maintaining sludge digester and biogas generator units

Giving operational contracts to the private operators with experience of operating such plants with biogas generation units, who can maintain MLSS levels and operate the units efficiently that produce biogas

- Create dedicated biogas O&M teams and engage specialised operators with proven experience in anaerobic digestion and methane utilisation systems.
- Operational performance often determines whether methane recovery potential is realised.
- Successful methane recovery systems require specialised expertise in anaerobic digestion, sludge management, gas handling, and engine operations.
- ULB officials consistently reported that conventional wastewater treatment skills are often insufficient to operate methane recovery systems effectively.
- Strengthening operational capacity through dedicated O&M teams, specialised operators, and improved operating procedures can improve digester performance, reduce methane losses, and enhance electricity generation.

# Business factors affecting financial viability

Methane recovery becomes sustainable only when supported by viable revenue streams and reuse pathways.

## Revenue Streams

- Electricity generation remains the dominant utilisation pathway.
- Limited examples exist for gas bottling and CBG production.
- Treated water and sludge reuse remain underutilised.

## Strong Backward And Forward Linkages

- Strong backward linkages support methane generation.
- Strong forward linkages improve resource utilisation.

## Cost recovery

- High O&M costs affect viability.
- Engine replacement costs are significant.
- Electricity savings improve economics.

## Scale Economics

- Larger plants benefit from economies of scale.
- Smaller plants require simplified business models.

- Financial viability is a critical factor influencing methane recovery at STPs.
- While electricity generation remains the primary utilisation pathway, long-term sustainability depends on developing multiple revenue streams and strengthening backward and forward linkages.

# Methane recovery becomes sustainable when energy savings are combined with multiple resource recovery pathways.



- The financial sustainability of methane recovery systems depends on both reducing operational costs and creating additional revenue streams.
- Develop multiple revenue streams to reduce dependence on electricity generation alone.
- Cities that combine energy savings with treated water reuse, sludge reuse, carbon credits, or CBG production are better positioned to maximise resource recovery and improve project viability.
- Strong backward linkages, such as reliable feedstock availability, and forward linkages, such as energy and reuse markets, are critical for long-term sustainability.
- Diversifying revenues through electricity savings, treated water reuse, sludge reuse, carbon credits, and CBG production improves project bankability.

# Governance factors affecting methane recovery

Governance and contract design determine whether methane is treated as a resource or merely a by-product.

## Contract Structure:

- Methane recovery is not prioritised in plant operations.
- Contracts often lack methane-related performance clauses (PCMC, Nashik).
- Methane recovery is rarely incentivised.
- Contracts must balance treatment compliance and resource recovery.

## Policy Environment:

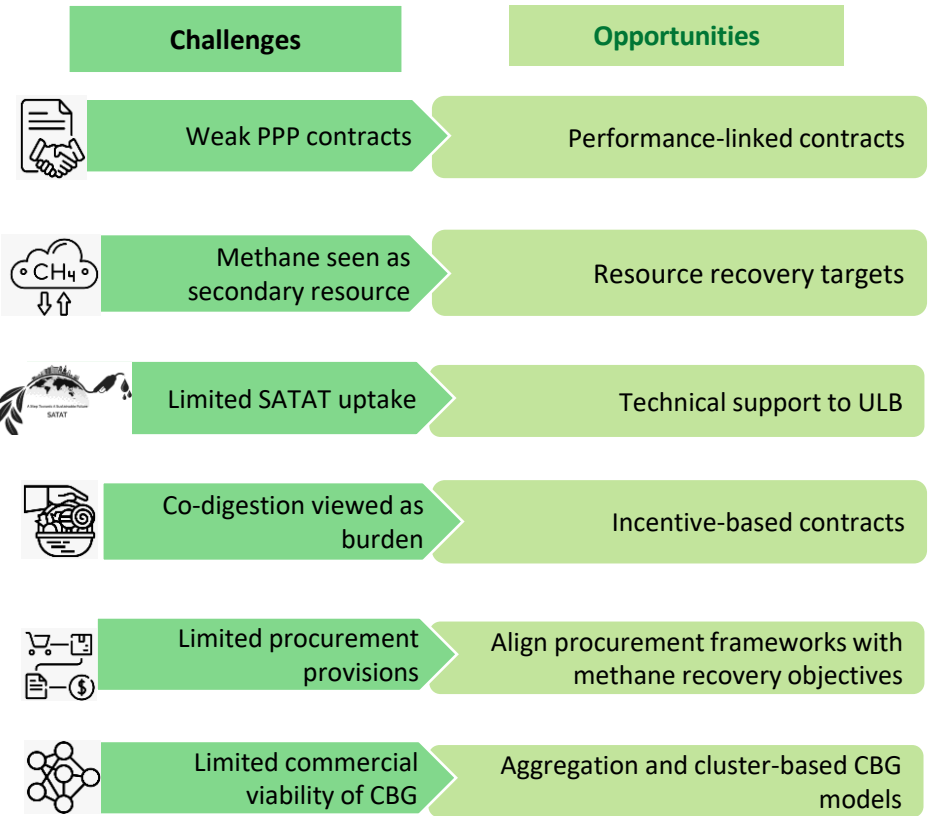
- Methane recovery is often viewed as a secondary objective.
- SATAT provides opportunities for CBG production and resource recovery.
- Procurement provisions for methane recovery remain limited in many cities.

## Institutional Capacity

- ULB expertise in methane recovery remains limited.
- Co-digestion requires additional infrastructure and O&M oversight.
- Commercial-scale CBG is more feasible for larger STPs.
- Smaller STPs may require aggregation or cluster-based models.

- Existing contracts focus primarily on effluent quality compliance, with limited incentives for methane generation and resource recovery.
- ULB officials indicated that operators are unlikely to adopt co-digestion practices unless supported through contractual incentives and performance-linked payments.
- SATAT creates an enabling framework for CBG production; however, most ULBs lack the technical, institutional, and financial capacity to leverage these opportunities effectively.
- Most existing contracts prioritise effluent quality compliance, while methane generation and resource recovery outcomes are rarely linked to operator incentives.
- Procurement and implementation frameworks for methane recovery need strengthening.

# Supportive governance frameworks are necessary to transform methane recovery from an optional activity into a core operational objective



- The assessment shows that governance and contractual arrangements play a critical role in determining methane recovery outcomes.
- Existing contracts primarily focus on effluent quality compliance, while methane generation and utilisation are rarely linked to operator incentives. Integrating methane recovery targets into contracts can improve accountability and resource recovery outcomes.
- Performance-linked contracts, resource recovery targets, and dedicated institutional support can encourage operators to optimise methane generation and utilisation.
- National initiatives such as SATAT provide opportunities for CBG production and methane utilisation; however, most ULBs currently lack the technical, financial, and institutional capacity required to leverage these opportunities.
- Procurement frameworks should incorporate methane recovery and resource recovery technologies, supported by updated cost benchmarks and technical guidance to facilitate implementation by ULBs.
- Based on the documented cases, larger STPs appear better positioned for commercial-scale CBG production, while smaller facilities may require aggregation or cluster-based approaches to achieve viable production scales.

# Monitoring factors affecting methane recovery

What gets measured gets managed; methane recovery cannot be improved without dedicated monitoring systems.

## ***Data Availability:***

- Methane generation data is often unavailable.
- Gas losses remain largely unquantified.
- There is no single portal or online data on STPs with methane capture units

## ***SCADA Systems:***

- Real-time monitoring improves operational control.

## ***Performance Tracking / Monitoring Systems:***

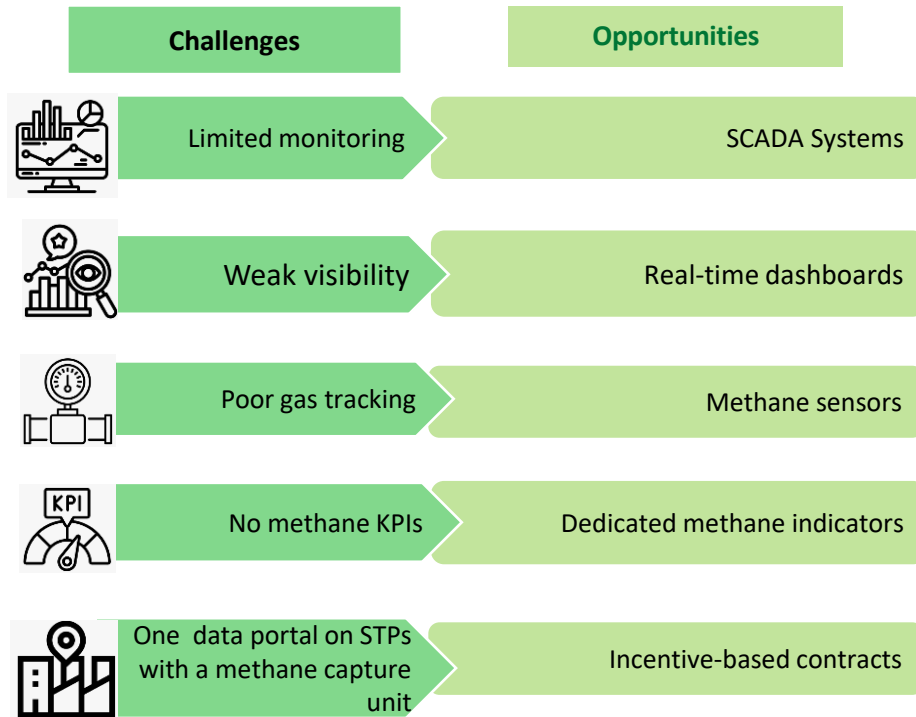
- Most plants monitor effluent quality only.
- Methane recovery indicators are rarely tracked.

## ***Decision Support:***

- Monitoring supports optimisation and preventive maintenance

- Across the studied plants, weak monitoring systems often contribute to the reduction in the actual methane recovery.
- Monitoring sludge quality, gas production, methane concentration, and energy conversion efficiency is essential for improving methane recovery, but it's absent in many STPs.
- Most plants monitor effluent quality but do not systematically track methane generation, methane leakage, engine efficiency, or electricity generation performance.
- Absence of Real-time monitoring systems, such as SCADA, reduces operational control and early identification of performance losses.

# Data-driven monitoring is essential for improving methane recovery efficiency and reducing operational losses.



- Data-driven monitoring enables operators to optimise plant performance while maintaining treatment standards.
- Monitoring systems provide the foundation for improving methane recovery performance.
- Real-time monitoring of gas production, methane concentration, sludge quality, and energy generation enables operators to identify losses, optimise operations, and improve decision-making.
- Integrating methane recovery indicators alongside wastewater treatment performance indicators can help shift plant management towards a more resource recovery-oriented approach.
- If the portal on STPs with a methane capture unit is there under SATAT scheme or as a separate portal under MoHUA's missions like AMRUT or SBM, then the skilled private operator can approach such cities to take advantage of the government schemes and can enhance methane production and reuse to make it a viable project.

# Key learnings

- Technology upgrades should improve methane recovery while ensuring compliance with wastewater effluent quality standards
- Maintaining digester health, bacterial culture, sludge quality, and MLSS levels is critical for stable methane generation.
- Reduce methane leakage at STP for optimum utilisation at STP
- Skilled operators directly influence methane recovery performance.

- Wastewater treatment performance and effluent quality compliance must remain the primary objective of STPs.
- Strong sludge input quality control and monitoring mechanisms
- SCADA and real-time monitoring to improve methane capture efficiency

## Technical aspects with O&M

Input quality of wastewater as well overall operations impact methane generation



01

## Monitoring

Effective sludge management at STP by skilled labors



02

03

## Governance

Use performance-linked contracts and enable government schemes like SATAT to strengthen forward and backward linkages



## Business model

Making methane recovery bankable by strengthening contractual terms and studying market potential

04

- **Often ignored but critical for effective methane capture and reuse at STPs**
- Treating methane as a resource through clear contractual and policy clauses
- Strong backward and forward linkages are essential to maximise resource recovery and minimise methane flaring.
- Methane recovery systems must be financially viable and contribute to reducing overall O&M costs.

- Dedicated operators, strong monitoring systems, and performance-linked contracts are more important than technology alone.
- SATAT provides opportunities for scaling methane utilisation, but ULBs require technical, financial, and institutional support to benefit from it.

• Improvements in technology alone are insufficient unless supported by skilled operators, strong monitoring systems, enabling governance frameworks, and financially viable business models. An integrated approach is therefore essential for transforming methane recovery potential into actual climate and financial benefits

• By improving plant efficiency, reducing methane losses, strengthening operational systems, and developing stronger resource recovery pathways, cities can convert wastewater treatment plants into climate-responsive resource recovery facilities

“

*Transforming STPs from wastewater treatment facilities into resource recovery systems can help cities reduce emissions, lower O&M costs, improve financial sustainability, and contribute to India's climate goals.*

”

# Thank you

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AND SANITATION

**CRDF** CEPT RESEARCH  
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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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