MOBILE PLANT TO FULL-SCALE FACILITY: PERFORMANCE COMPARISON

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Executive summary

The operation of 2,700 tonnes of MSW in the **Mobile Plant**, a semi-mobile anaerobic digestion (AD) installation containing 6 containers with dimensions 12x2.4x2.4 meters situated in **Nagpur, India**, has provided **valuable insight** over the past months into the technical and biological performance of **WTT's dry anaerobic digestion** technology on a smaller scale, specifically for the Indian MSW. While the Mobile Plant has demonstrated that under optimized and stable conditions close to 3.5% of Compressed Biogas (CBG) per tonne of input is achievable in a compact and mobile setup, the experience also highlights the clear benefits of scaling up. WTT expects that reaching **4.0% of CBG**, or potentially even **up to 4.5%** of the input waste, is possible.

WTT is confident that the Full-Scale Facility offers significant advantages in terms of process stability, performance reliability, and long-term biogas production.

- With a throughput capacity of over 230,000 tonnes per year, the full-scale system is built to handle fluctuations in waste quality and volume, including seasonal variations. CBG yields of at least **4%** are expected to be achieved
- A longer Hydraulic Retention Time allows for more complete digestion, leading to higher and more stable gas yields.
- The presence of a sedimentation tank ensures consistent leachate flow and helps to manage pH-fluctuations, which are often the cause of biological instability in smaller systems.
- Thermal insulation and a larger thermal mass provide a more stable environment for microbial activity, improving overall plant efficiency even during cold seasons.
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“The Mobile Plant proves the concept, while the Full-Scale Facility will prove the potential.”

Introduction

India faces growing challenges in managing its organic municipal waste due to rapid urbanization, limited landfill space, and an increasing need for sustainable waste-to-energy solutions. Waste Treatment Technologies (WTT) develops dry anaerobic digestion (AD) facilities all around the world. The Mobile Plant (MP), sometimes also referred to as Mobile Waste Plant (MWP) or Transportable Biogas Plant (TBP), has specifically been developed to serve as a proof-of-concept for its dry anaerobic digestion technology, specifically adapted to Indian waste characteristics.

This document aims to present the technical performance and operational data of the MWP, which has been actively processing mixed organic waste under field conditions over the past several months. While compact in scale, the MWP replicates the key biological and mechanical processes of a full-scale AD facility and provides valuable insights into the feasibility of implementing this technology at larger scale in India. By validating biogas production potential, operational stability, and adaptability to local waste compositions, the MWP forms a critical step toward derisking investments in full-scale installations.

This paper is intended to support in evaluating the technical robustness and economic viability of WTT's AD solution within the Indian context.

The MWP demonstrates that dry AD is both technically feasible and environmentally beneficial for Indian MSW. Its performance data serves as a foundation for scaling to a full-scale facility, with enhanced efficiency, greater process stability, and long-term economic impact.

Method

The MWP is designed to process a mixed organic waste stream composed of shredded green waste and municipal solid waste (**MSW**) pre-treated to a particle size of **<80 mm**.

The estimated total throughput for the installation is 2,700 tonnes per year, based on continuous operation. The filling schedule consists of filling two new tunnels per week, with each tunnel receiving approximately **26 tonnes** of fresh material. This results in a total of 52 tonnes of input per week, which translates to the annual throughput of **2,700** tonnes.

The incoming material is assumed to be characterized as 40% Dry Solids (DS) of which 77% Organic Dry Solids (ODS). These values indicate that the waste stream has a **high biodegradable content**, suitable for anaerobic digestion. The total estimated input of ODS is approximately **833 tonnes** per year, but not all this material is expected to degrade during the digestion process. Based on process characteristics and substrate biodegradability, the expected actual ODS degradation is approximately **313** tonnes (ca. 37.5%)

Using a projected biogas yield of **800** Nl/kg degraded ODS, the total biogas production potential is ca. **250.000m³** biogas per year, with a methane/CO2 ratio of ca. 50/50%.

In the full-scale facility, biogas production is enhanced by the circulation of liquid percolate from the fermentation tank, which is used to irrigate the anaerobic tunnels. This liquid flow promotes even moisture distribution and microbial activity throughout

the waste mass, supporting efficient anaerobic degradation in the fermentation tank and the anaerobic tunnels. Therefore, this is replicated in the MWP.

Each tonne of fresh waste material loaded into the tunnels is irrigated with approximately **1.2** m³ of percolate. Based on an annual throughput of 2,700 tonnes, the total percolate volume circulated annually is **3240**m³ per year.

The fermentation tank has a working volume of 40 m³, which serves as the buffer and biological reactor for the liquid phase of the system. The hydraulic retention time (**HRT**) for the MWP is **4.5 days**.

The MWP follows WTT's standardized approach to percolate irrigation, which is a critical parameter for process stability and biological activity in dry digestion systems. In accordance with WTT's guidelines, the MWP applies 1.2 m³ of percolate per ton of waste input. At the current average tunnel load, this results in an irrigation volume of ca. **29 m³** per tunnel.

This volume is applied over standard irrigation phases (1-5) of 84 hours each. During these 17.5 days, the entire 29 m³ is evenly distributed to maintain moisture content, support hydrolysis and acidogenesis, and sustain microbial activity in the early stages of digestion. After phase 5, the tunnel is finalized its irrigation batch and is draining for the next 3-4 days (phase 6) prior to the flushing stage.

Parameter AD Tunnel	Ph1	Ph2	Ph3	Ph4	Ph5
Batch volume (m3)	0.4	0.3	0.3	0.2	0.2
Batch interval time (h)	4	4	4	4	4
Total irrigation volume	8	7	6	4	4
Maximum time between 2 gas circulations (h)	2	2	2	2	2
Biogas phase duration (h)	84	84	84	84	84

Results

The MWP was successfully cold commissioned and started operations October 28th, 2024. Following the initial startup, a hot commissioning period of four weeks was carried out, during which all critical systems and process parameters were tested and verified.

The Mobile Waste Plant has been operational for a period of five months, during the timeframe November 2024 and March 2025. Its performance has varied due to several operational and environmental factors. Notably, a period of underperformance was observed between December and February, where gas production and overall biological activity fell short of expectations.

In response to the suboptimal outcomes during this period, WTT and SusBDe entered into a Service Level Agreement (SLA) that included dedicated onsite process assistance and remote process support. The implementation of this **SLA proved highly effective**: during the onsite support phase, the MWP achieved its highest daily biogas production (**485m³**).

WTT is confident that the observed peak performance reflects the true biogas potential of the MWP, provided the daily operations remains stable and well-managed. The performance conclusions and projections outlined in this report are therefore based on data collected during this stable period, representing realistic expectations under optimized operating conditions.

Below is a summary table of the calculated potential biogas production per day, based on the recorded weights and waste composition from 8th of March until 12th of March, considering the following:

- 114 tonnes of waste in 6 tunnels during these days
- 58% average DS concentration
- 52% average ODS concentration
- 50% CH_4 in the biogas
- 95% CH_4 in the CBG
- 0.801 m3 (@40ºC and 100% RH) to Nm^3
- 1.25 kg/Nm^3 density of biogas at 50% CH_4
- 0.78 kg/Nm^3 density of CBG at 95% CH_4
- 5-day results extrapolated to 21-day process

Date of results	Biogas [m3 from SCADA]	Biogas [Nm3]	CBG [kg]	CBG/ tonnes
08/03/25	455	364	187	3.45%
09/03/25	440	352	181	3.34%
10/03/25	430	344	177	3.26%
11/03/25	468	375	192	3.55%
12/03/25	485	388	199	3.68%

The results indicate that, even with a reduced ODS fraction and input tonnage, the biogas production during this period aligns well with the theoretical potential. As there's no CBG upgrading here, the **3,46% average** is calculated based on the abovementioned assumptions.

Discussion

The assumed biogas yield of 800 Nl/kg ODS is based on expected performance under optimal digestion conditions. However, this yield should be regarded as a theoretical estimate for indicative purposes only. It has not been validated by any GB21-analysis. As such, this value will be 10-25% lower in practise, and therefore this outcome proves that the Mobile Plant is actually overperforming.

In standard WTT-designed installations, the typical HRT lies between 8 and 12 days, compared to the 4.5 in the MWP due to the semi-mobile dimensional limitations. A longer HRT provides a more stable biology, a better buffer capacity with more time for microbial degradation and methane conversion. The short duration allows for little adaptation to feedstock fluctuations. Even small temperature or pH-shifts can cause imbalances. Therefore, in the full-scale facility, gas yield should be higher and the process more stable.

Another critical process parameter is the temperature, the insufficient insulation of the digestion tunnels, where the installed insulation materials do not meet WTT's prescribed thermal resistance values. This has resulted in temperature fluctuations, particularly during colder periods, which directly affect microbial activity in the digestion process.

A key feature contributing to process stability in the Full-Scale Facility that the Mobile Plant does not have, is the presence of a sedimentation tank, which plays a multiple role:

- The sedimentation tank acts as a flow buffer toward the fermentation pit, smoothing the hydraulic and organic load over time.
- Functions as a biological pH buffer, stabilizing percolate composition and reducing acidification risks in the fermentation cycle.
- Heavy particles (mostly inert) are settled down to the bottom of the sedimentation tank and are not pumped into the fermentation tank.

WTT expects that the sedimentation tank minimizes pH-fluctuations and enhances the biological robustness of the system: a distinct advantage over the Mobile Plant, which lacks such a buffering component.

The current operational data from the MWP reveals several key deviations from the original design specifications, particularly with respect to waste composition and throughput consistency. There is a significant difference in the actual waste characteristics compared to the initial design waste composition: the DS content is higher, indicating a drier substrate, the organic fraction of the dry solids which is directly responsible for biogas production, is substantially lower than expected. This reduced ODS concentration results in lower overall biogas yield potential per ton of waste input. In addition to the waste composition, the overall throughput volume is also lower than initially expected. This combination of lower organic content and reduced tonnage translates into a significant decrease in expected biogas production, even under optimized process conditions.

Parameter	Initial Assumption	Actual Values
Dry Solids (DS)	40%	~50%
Organic Dry Solids (ODS)	77% of DS	~54% of DS
Throughput	2,700 t	2,513 t
Biogas yield expectation	250,560 m³	209,968 m³

To better understand the efficiency and biological performance of the MWP, it is strongly recommended to implement a consistent sampling and analysis protocol for determining dry solids (DS), organic dry solids (ODS), and weight before and after the tunnel process per tunnel batch. Regularly performing GB21 tests (or equal) helps to more accurately determine the exact potential gas yield of the waste as well, and thus performance of the facility.

Conclusion

WTT guarantees a biogas production equivalent to a percentage of the GB21 gas potential, as determined by the standardized fermentation test outlined in DIN 38414-S8 or OENORM S 2027-3. With a long-term service level agreement (SLA), WTT believes we can “overperform”, hence the increased guaranteed values.

Plant	Without SLA	With SLA
Mobile Plant	60% of GB21-value	70% of GB21-value
Full-scale facility	70% of GB21-value	80% of GB21-value

Despite deviations in both waste composition and throughput, recent data from the MWP indicates that biogas production has been in line with expectations. This suggests that under stabilized conditions and with improved process support, the MWP can achieve its operational targets even with suboptimal substrate quality.

To evaluate this, a reverse-calculation was made based on the actual waste input weight, the measured dry solids (DS), and organic dry solids (ODS). The resulting theoretical biogas potential was estimated using a conservative methane yield of 300 Nl/kg fresh ODS.

Based on the current waste input characteristics and operational data, the MWP demonstrates performance that aligns with initial expectations in terms of biogas production potential. Even with the actual substrate having lower-than-expected organic content and the absence of high-yield food waste, the plant can achieve its gas yield targets considering biologically stable conditions.

Difference	Effect
Longer HRT	Increased gas yield Better process stability
Better insulation	Increased gas yield during colder periods Better process stability
Higher CH_4 concentration	Compared to the 50% assumption, expect a 5-10% increase in the full-scale facility

Major differences of the Mobile Plant compared to the Full-Scale Facility are summarized in the table above.

The Mobile Plant has given good data on various parameters of the process during the last 5 months. This compositional inconsistency places additional stress on the digestion process. One of the primary causes could be the high variability in C/N ratio, potentially influenced by:

- Seasonal changes in household waste behaviour.
- Public events and festivals, leading to changes in waste composition.
- Fluctuations in the balance of carbohydrates, fibres, and fats, affecting digestibility/microbial dynamics.
- However, this variation is in line with expectations

We continue to further study the operational parameters parallel to the construction of the full-scale plant and current data indicates that the full-scale facility processing 275.000 tonnes per annum will have a more stable operation and CBG yields of at least 4% are expected to be achieved.