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Transforming Kitchen Waste into Biogas through Community Empowerment in Petamburan

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Abstrak

Permukiman perkotaan padat menghadapi keterbatasan pengolahan sampah organik, pemilahan rumah tangga yang belum konsisten, dan rendahnya keterampilan pengoperasian teknologi biogas. Program pengabdian ini bertujuan meningkatkan kapasitas warga RT 009 Petamburan, Jakarta Pusat, dalam mengolah sampah dapur menjadi energi dan pupuk organik. Kegiatan dilaksanakan melalui sosialisasi, pelatihan praktik, penerapan teknologi, pendampingan dan evaluasi, serta penguatan keberlanjutan. Sebanyak 23 warga mengikuti kegiatan dan lima orang ditetapkan sebagai operator. Digester berkapasitas 1.400 liter dipasang dan diisi awal dengan 200 kg kotoran sapi segar sebagai inokulum, kemudian diberi sampah dapur terpilah secara bertahap. Rata-rata pengetahuan pemilahan meningkat dari 72,61 menjadi 100,00, sedangkan pengetahuan biogas meningkat dari 71,88 menjadi 93,62. Slurry mulai tertampung pada minggu kedua dan biogas yang mengandung metana terdeteksi pada minggu keempat. Integrasi teknologi, pelatihan, SOP, logbook, dan pengelolaan berbasis warga meningkatkan pengetahuan serta kesiapan operasional mitra.

Kata kunci: ***Biogas, Sampah Dapur, Pemberdayaan Masyarakat, Teknologi Tepat Guna, Slurry.***

Abstract

Dense urban settlements face limited organic-waste treatment capacity, inconsistent household waste sorting, and insufficient skills in operating biogas technology. This community engagement program aimed to strengthen the capacity of residents of Neighborhood Unit 009, Petamburan, Central Jakarta, to convert kitchen waste into energy and organic fertilizer. The program involved community outreach, hands-on training, technology deployment, mentoring and evaluation, and sustainability strengthening. Twenty-three residents participated, and five were appointed as local operators. A 1,400-L digester was installed and initially charged with 200 kg of fresh cow manure as the microbial inoculum, followed by the gradual addition of sorted kitchen waste. The mean waste-sorting knowledge score increased from 72.61 to 100.00, while the biogas-technology score increased from 71.88 to 93.62. Slurry was first collected during the second week, and methane-containing biogas was detected during the fourth week. Integrating appropriate technology, practical training, standard operating procedures, an operational logbook, and resident-led management improved community knowledge and operational readiness.

Keywords*: *Biogas, Kitchen Waste, Community Empowerment, Appropriate Technology, Slurry.

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Introduction

Rapid population growth and changing consumption patterns have increased the volume and diversity of municipal solid waste, particularly food and kitchen waste (Mirnayani & Suwandari, 2024). In densely populated urban settlements, organic waste is commonly mixed with plastics, metals, glass, and other non-biodegradable materials before being transported to temporary disposal sites. This practice causes unpleasant odors, attracts disease vectors, increases transportation loads, and prevents the recovery of energy and nutrients from biodegradable materials. Indonesian waste-management policy emphasizes integrated waste reduction and treatment from the source, with active community participation and the recovery of environmental and economic value from waste (Government of DKI Jakarta., 2021). Therefore, neighborhood-based organic-waste management is important for supporting a circular and sustainable urban-waste system (Usman & Can, 2022).

Anaerobic digestion is considered a reliable technology for converting biodegradable waste into biogas and nutrient-containing digestate. It can reduce the volume of organic waste while recovering renewable energy and organic fertilizer (Rahmat, 2023). However, system performance is influenced by feedstock composition, particle size, organic loading, temperature, pH, dilution, and feeding consistency (Dhungana et al., 2022;Yaqub et al., 2020). Appropriate pre-treatment and controlled feeding can improve microbial access to organic materials and reduce the risk of blockage and process instability. Small-scale and household biodigesters are also suitable for decentralized waste treatment, although their sustainability depends on user participation, regular feedstock supply, operational discipline, and continuous performance monitoring (Ebel et al., 2025;Meegoda et al., 2025).

The target partner was the resident group of Neighborhood Unit 009, Petamburan, Central Jakarta. The preliminary assessment identified two main problem areas: production and social-community capacity. In the production aspect, household kitchen waste had not been consistently separated, the quality and quantity of organic feedstock varied, and no collection schedule or standardized pre-treatment procedure was available. Before the program, the partner had no organic-waste shredder, community digester, gas-storage equipment, biogas stove, or digestate container. Consequently, kitchen waste was generally transported with mixed municipal waste rather than processed locally into useful products.



Figure 1. Baseline Conditions of the Community Partner
(Source: Program documentation, 2026)

In the social-community aspect, residents had limited knowledge and practical experience related to organic-waste sorting, feedstock preparation, digester feeding, installation maintenance, methane safety, and slurry utilization. The partner also had

no resident operator team, standard operating procedures, duty schedule, or operational logbook.

The work program was designed to integrate appropriate technology with community empowerment. It comprised five stages: socialization, practical training, technology deployment, mentoring and evaluation, and sustainability strengthening. The technology package included a 1,400-L fiberglass digester, an organic-waste shredder, mixing and slurry containers, gas piping, valves, a manometer, a filter, a gas-storage bag, and a biogas stove. The system was intended to serve approximately 10–20 participating households. The program also included the preparation of operational and safety procedures, an operational logbook, a duty schedule, and the establishment of a five-member resident operator team.

Accordingly, this community engagement program aimed to improve the capacity of Petamburan residents to separate and process kitchen waste using a biogas installation. Specifically, the program sought to provide appropriate waste-processing technology, improve residents' knowledge and operational skills, establish a local operator team, implement safety and recording procedures, and initiate the production of biogas and slurry. The expected benefits included reduced organic-waste disposal, improved environmental awareness, increased community participation, locally produced renewable energy, and the potential utilization of slurry as organic fertilizer for neighborhood plants and green spaces.

Implementation Method

1. Place and Time of Implementation

The community engagement program was conducted in Neighborhood Unit 009, Petamburan Urban Village, Tanah Abang District, Central Jakarta. The program was implemented from July to August 2026. The equipment was received and inspected jointly with the community partner on 9 July 2026. The biogas installation was completed on 17 July 2026, while socialization and practical training were conducted on 18 July 2026 from 09:00 to 16:00. Following the installation and training, mentoring and operational monitoring were undertaken.



Figure 2. Location of Neighborhood Unit 009, Petamburan, Central Jakarta
(Source: Program documentation, 2026)

2. Target Audience and Community Partner

The socialization and training activities involved 23 residents. Five participants (Lani, Ferdi, Marwan, Pardi, and Ubay) were appointed as members of the Resident Operator Team. The operators worked under the responsibility of Ircham, the community partner leader and neighborhood head, and coordinated with Mirnayani, the program leader. The operators were selected based on their willingness, proximity

to the installation, participation in the training, and commitment to performing scheduled duties.

3. Service Methods

The program applied a participatory approach that integrated education, practical training, appropriate-technology deployment, mentoring, and evaluation. The implementation consisted of five main stages, as presented in Table 1.

Table 1. Implementation methods

No.	Target	Implementation methodology	Success indicator	Evaluation method
1	Improve residents' understanding of kitchen-waste separation	Socialization concerning acceptable and prohibited digester inputs, collection procedures, and contamination prevention	Knowledge scores increase, and participants can correctly identify suitable materials	Pretest–posttest, questions and answers, and observation of sorting practices
2	Improve feedstock pre-processing skills	Demonstration and practice of shredding, water mixing, and preparing materials for digester feeding	Participants can shred and prepare feedstock according to the procedure	Skills-observation sheet and activity documentation
3	Provide local organic-waste processing technology	Installation of a 1,400-L digester, shredder, gas piping, valves, manometer, filter, gas bag, and biogas stove	One complete biogas system is installed and operationally ready	Component inspection, leak testing, and functional testing
4	Improve knowledge and skills in biogas operation	Training in digester feeding, pipe and valve inspection, stove use, maintenance, and occupational safety	Biogas-knowledge scores increase, and operators can follow the SOP	Pretest–posttest, safety simulation, and observation of practical activities
5	Establish community-based operational governance	Formation of the Resident Operator Team, task allocation, duty scheduling, SOP preparation, and logbook provision	Five operators are appointed with clearly defined responsibilities and recording procedures	Examination of the operator list, SOP, duty schedule, and logbook
6	Initiate biogas and slurry production	Initial charging with 200 kg of livestock manure, followed by gradual feeding of separated kitchen waste	Slurry is collected, and methane gas is produced	Observation of the slurry outlet, gas-bag inspection, flame testing, and recording of formation time
7	Strengthen program sustainability	On-site mentoring, communication through a WhatsApp group, installation inspection, and periodic monitoring	Operators gradually perform feeding, inspection, and recording activities	Field observation, operator interviews, and operational-logbook examination

Source: Community engagement team, 2026.

4. Technology Deployment Stages

Technology deployment began with a site inspection and preparation of the installation base. A 1,400-L fiberglass digester was subsequently installed and connected to the feed inlet, slurry outlet, gas pipeline, valves, manometer, filter, gas-storage bag, and biogas stove. The digester was initially charged with 200 kg of livestock manure to provide anaerobic microorganisms. Thereafter, kitchen waste was separated, inspected, shredded, mixed with water, and gradually introduced into the digester.

5. Success Indicators

Program success was assessed using production and social-community indicators. Production indicators included the availability of one biogas installation, a waste shredder, gas-utilization equipment, a slurry container, the completion of initial charging, slurry collection, and methane formation. Social-community indicators included the participation of 23 residents, increased knowledge scores, the appointment of five operators, the availability of an SOP and logbook, and the operators' ability to perform basic operational and safety procedures.

6. Evaluation Method

Knowledge improvement was evaluated using pretests and posttests completed by 23 participants. The data were analyzed using mean scores, score differences, and normalized gain. Skills were evaluated by observing waste separation, shredding, digester feeding, connection inspection, stove use, and safety simulations. Technology implementation was evaluated through physical inspection, slurry-outlet observation, gas-bag inspection, leak testing, and flame testing. Program sustainability was evaluated through operator interviews, field monitoring, and examination of the SOP, duty schedule, and operational logbook.

Result and Discussion

1. General Program Achievements

The community engagement program combined appropriate-technology deployment with resident capacity building. The main achievements included the installation of a community biogas system, increased residents' knowledge, the establishment of a Resident Operator Team, and the initial production of slurry and methane gas. The technology package consisted of a 1,400-L fiberglass digester, an organic-waste shredder, mixing and slurry containers, gas piping, valves, a manometer, a gas filter, a gas-storage bag, and a biogas stove.

Before the program, the partner had no equipment for processing kitchen waste into energy or organic fertilizer. Household organic waste was not consistently separated, and residents had no experience in operating an anaerobic digester. After the intervention, the partner had an integrated system covering household sorting, collection, shredding, mixing, digester feeding, gas utilization, slurry collection, and operational recording. The comparison as presented in Table 2.

Table 2. Comparison of partner conditions before and after the program

Aspect	Before the program	After the program	Achievement
Organic-waste separation	Inconsistent and frequently mixed with inorganic waste	Labeled containers and sorting procedures were introduced	Implemented
Feedstock pre-processing	No shredding equipment	One organic-waste shredder and mixing containers were provided	100%

Aspect	Before the program	After the program	Achievement
Organic-waste processing	No processing technology	One 1,400-L community digester was installed	100%
Gas-utilization system	Unavailable	Gas piping, filter, gas bag, and biogas stove were installed	100%
Slurry handling	No collection facility	Slurry outlet and collection container were provided	100%
Resident operators	No dedicated operators	Five residents were appointed as operators	100%
SOP and logbook	Unavailable	Operational and safety SOPs and a logbook were provided	100%

Source: Field observations and program documentation, 2026

2. Technology Installation and Initial Operation

The installation was completed on 17 July 2026. The digester was placed in a location that was accessible to the operators and did not interfere with residents' daily activities. The installation process included preparing the base, positioning the digester, and connecting the inlet, slurry outlet, gas piping, valves, manometer, filter, gas-storage bag, and biogas stove. Safety equipment, including personal protective equipment, a fire extinguisher, and a gas detector, was also provided.

The digester was initially charged with 200 kg of livestock manure as inoculum. Livestock manure was used to provide the anaerobic microorganisms required to initiate the decomposition process. After the initial charging, separated kitchen waste was gradually added. Before feeding, the waste was inspected to remove plastics, metals, glass, bones, excessive oil, and chemical contaminants. The acceptable organic materials were shredded and mixed with water to obtain a more uniform feedstock.



Figure 3. Existing household waste-sorting facilities, organic kitchen-waste collection, and educational materials at the community partner's location in RT 009 Petamburan *(Source: Program documentation, 2026)*



Figure 4. Installation biogas digester *(Source: Program documentation, 2026)*



Figure 5. Installed community biogas digester, gas distribution pipeline, and biogas stove at RT 009 Petamburan. *(Source: Program documentation, 2026)*



Figure 6. Initial filling and operation of the biogas digester using fresh cow manure as the microbial inoculum. *(Source: Program documentation, 2026)*



Figure 7. Demonstration of organic kitchen-waste shredding and the resulting feedstock for the community biogas digester. *(Source: Program documentation, 2026)*

3. Initial Formation of Slurry and Methane Gas

The first slurry was collected through the digester outlet during the second week of operation. This result indicated that the material had begun to move through the system and that the outlet functioned properly. The slurry was temporarily collected in a designated container for subsequent utilization as organic fertilizer. At this stage, the volume and nutrient composition of the slurry had not yet been quantitatively analyzed. Therefore, its fertilizer performance still requires further testing through a small demonstration plot.

Methane gas was produced during the fourth week of operation. Gas formation was indicated by gas accumulation in the storage bag and the functional testing of the biogas system. The difference between the initial appearance of slurry in the second week and methane production in the fourth week reflected the start-up phase of anaerobic digestion. During this phase, microorganisms require time to adapt to the substrate and establish stable hydrolysis, acidogenesis, acetogenesis, and methanogenesis processes.

Table 3. Initial operational development of the biogas installation

Operational period	Observed development	Interpretation
Initial charging	The digester was filled with 200 kg of livestock manure	Anaerobic inoculum was introduced
First week	Kitchen waste was gradually introduced	Microbial adaptation and substrate decomposition began
Second week	The first slurry was collected from the outlet	Material circulation and the slurry outlet began functioning
Third week	Gas accumulation was monitored	The digestion process continued toward methane formation
Fourth week	Methane gas was produced	The system entered the initial biogas-production stage

Source: Operational observations and logbook, 2026.

The results are consistent with the principle that household and community-scale digesters require a start-up and microbial-adaptation period before methane production becomes observable. Feedstock consistency and regular monitoring are essential because fluctuations in kitchen-waste composition can affect digestion stability and gas yield (Rasullia Kamandang et al., 2024). The results obtained during the first four weeks demonstrate initial system functionality but cannot yet be used to determine long-term gas productivity.



Figure 8. Initial slurry collection and methane-gas formation
(Source: Program documentation, 2026)

4. Improvement in Residents' Knowledge

Knowledge improvement was assessed using pretests and posttests completed by 23 participants. Two domains were evaluated: kitchen-waste separation and biogas technology. The mean waste-sorting score increased from 72.61 in the pretest to 100.00 in the posttest, representing an increase of 27.39 points. The mean biogas-technology score increased from 71.88 to 93.62, representing an increase of 21.74 points. The normalized gain was 1.00 for waste sorting and 0.77 for biogas technology. Both values were classified as high.

Table 4. Pretest and posttest results of the participants

Knowledge domain	Pretest mean ± SD	Posttest mean ± SD	Increase	N-gain	Category
Kitchen-waste separation	72.61 ± 6.89	100.00 ± 0.00	27.39 points	1.00	High
Biogas technology	71.88 ± 4.47	93.62 ± 3.75	21.74 points	0.77	High

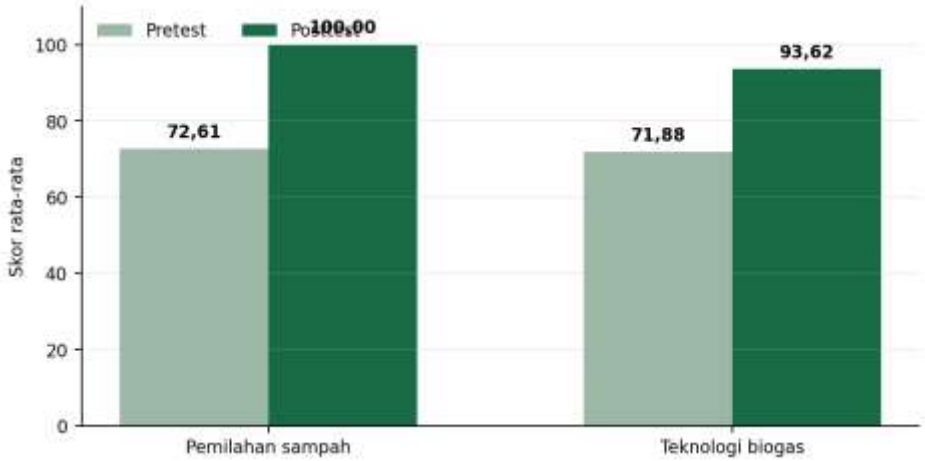


Figure 9. Comparison of participants' mean pretest and posttest scores
Source: Processed program evaluation data, 2026.

A perfect sorting posttest indicates immediate mastery of the tested items but also creates a ceiling effect. Follow-up evaluation should therefore measure actual household behavior, contamination rates, and collection consistency rather than merely repeat the same knowledge test. The biogas posttest did not reach a uniform maximum, reflecting the greater complexity of feeding, leak detection, troubleshooting, and maintenance. Knowledge gain should be interpreted as readiness for supervised practice, not proof of full long-term operational independence.

Training combined presentation, discussion, demonstration, and direct practice. Residents learned allowable and prohibited inputs, shredding and dilution, feeding, valve and connection checks, stove use, soap-solution and gas-detector leak tests, initial emergency responses, and digestate handling. Practical exposure linked the information to the equipment installed in the neighborhood. Community engagement is central to waste-system sustainability because routine source separation and feedstock supply depend on household participation and shared responsibility (Akhai, 2023).



Figure 10. Socialization, demonstration, and hands-on practice
Source: Program documentation, 2026

A five-member local operator team was formed. Lani was assigned to material receipt, sorting checks, and weighing records; Ferdi to shredding, mixing, and feeding; Marwan to connection, pipe, valve, manometer, and gas-bag checks; Pardi to site cleanliness, safety, leak checks, and stove support; and Ubay to logbook documentation, collection records, and digestate utilization. All five operators received task assignments, SOP instruction, safety simulation, and logbook training.

Table 5. Social skills and institutional achievements

Social indicator	Before the program	Achievement	Status
Training participation	No organized activity	23 residents completed the core activity	23 participants
Resident operator team	0 operators	Five operators appointed	100% of the maximum target
Task allocation	Unavailable	Tasks assigned to 5/5 operators	100%
SOP and safety training	Unavailable	5/5 operators trained and involved in simulation	100%
Logbook and reporting flow	Unavailable	Format available; 5/5 operators trained	100% operator readiness
Independent routine operation	Not applicable	Still under mentoring	Final status not yet assessed

Source: Attendance, assignment, observation, and training records, 2026

The operator team, SOP, and logbook serve complementary functions. Local operators create ownership and enable rapid responses. The SOP reduces procedural variability and safety risks. The logbook turns daily operation into evaluable information. However, broader participation remains essential because reliable feedstock depends on household sorting behavior. The major initial constraints were irregular organic-waste collection, limited operator experience, incomplete productivity records, and unmeasured digestate utilization.

Table 6. Initial constraints and corrective actions

Constraint	Operational implication	Follow-up action
Irregular organic-waste supply	Feeding and gas formation may become unstable.	Strengthen household sorting, set collection days, weigh inputs, and record contamination.
Limited operating experience	Procedures and responses to disturbances may vary.	Continue mentoring, safety simulations, and SOP-compliance checks.
Incomplete productivity data	Energy and fertilizer benefits cannot yet be quantified.	Record input mass, water ratio, feeding, pressure indicators, flame duration, digestate, disturbances, and corrective action.
Digestate use not measured	The value of the co-product remains unverified.	Establish a small demonstration plot with recorded dilution, dose, and plant response.

Source: Program monitoring, 2026

The evaluation has several limitations. It used one group without a comparison group, and the posttest was administered close to the training date; consequently, the findings mainly represent immediate learning rather than long-term retention. The sorting instrument showed a ceiling effect. Technical output indicators also remained incomplete during the reporting period. Future evaluation should combine delayed testing, observed sorting accuracy, operator-compliance audits, and at least eight to twelve weeks of routine input-output records.

Conclusion

The program successfully installed a 1,400-L community biogas system and established the initial governance required for kitchen-waste treatment in Petamburan. Initial charging used 200 kg of livestock manure, followed by gradual feeding of sorted kitchen waste. Among 23 participants, waste-sorting knowledge increased from 72.61 to 100.00, and biogas knowledge increased from 71.88 to 93.62, with statistically significant changes in both domains. A five-member resident operator team was supported by task allocation, safety procedures, and a logbook. The principal contribution is the integration of appropriate technology, hands-on learning, and neighborhood-level governance. Routine feedstock supply and quantified gas and digestate performance remain the priorities for continued mentoring and evaluation.

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