UNIVERSITY OF CAMBRIDGE
Department of Engineering

IfM Centre for Industrial Sustainability

P2G
Plastic to Ghar
प्लास्टिक देखि घर

P2G Technical Toolkit

Plastic Upcycling Processes & Practices

2025 WINNER
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Front Page
Ashutosh from KleanIt Upcyclers working on extrusion to produce plastic lumber. N.B. This image depicts an operation conducted without proper personal protective equipment. Much as we love the dynamic moment we've captured, we strongly recommend against replicating this practice and urge all operators to ensure that appropriate personal protective equipment is worn at all times.

Disclaimer

This report is an output of research funded by the Sustainable Manufacturing and Environmental Pollution (SMEP) Programme.

The project, *Plastic 2 Ghar (P2G) Plastic Waste Remanufacturing for Local Housing: Innovation Ecosystem in Nepal* (Principal Investigator: Prof. Steve Evans, grant number G114346), is implemented by the University of Cambridge and Impact Hub Kathmandu, has been awarded a UK International Development grant in order to establish plastic waste innovation ecosystems in Nepal. The grant has been made via the SMEP Programme and has been awarded until 30th June 2026.

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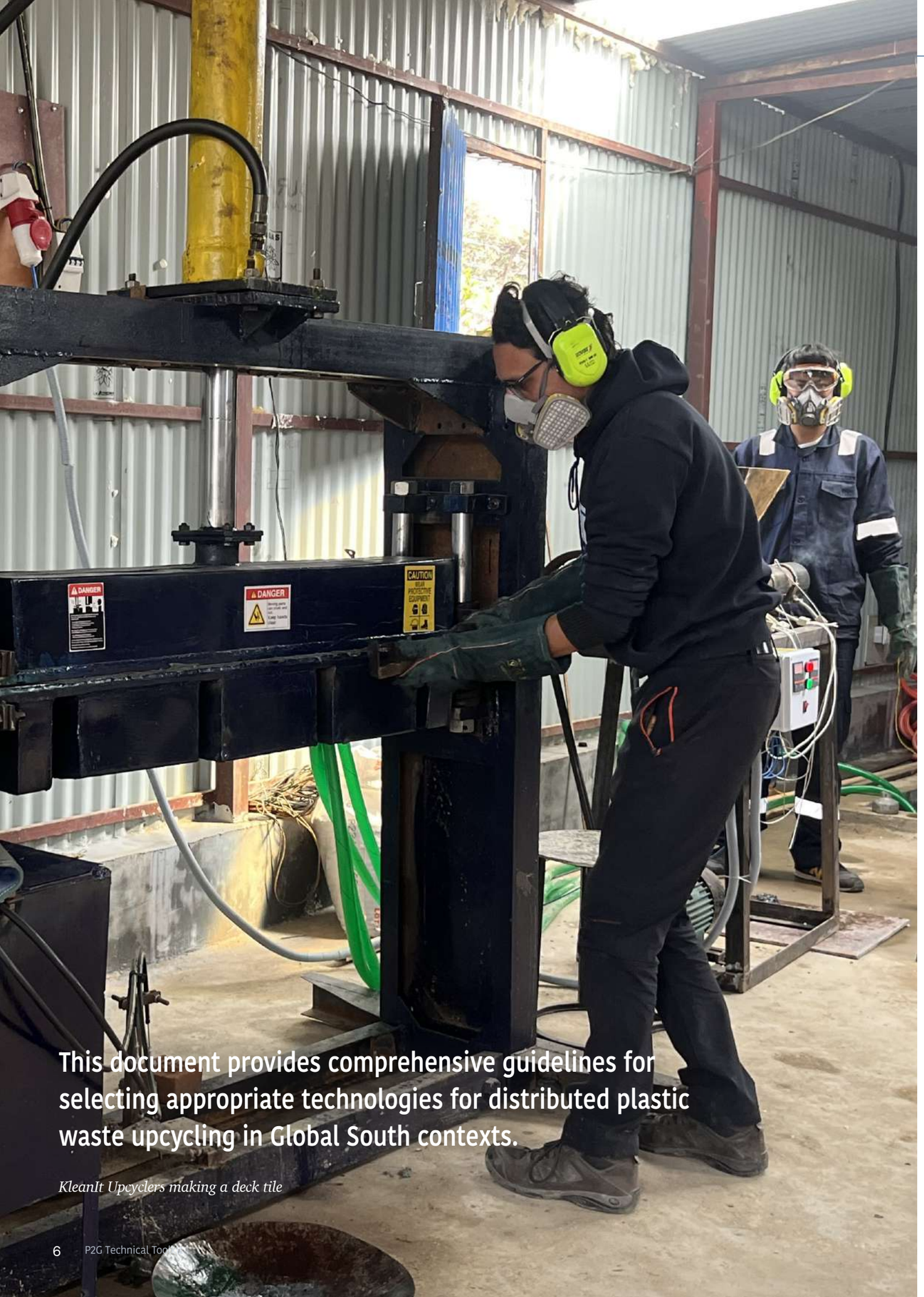

This document provides comprehensive guidelines for selecting appropriate technologies for distributed plastic waste upcycling in Global South contexts.

KleanIt Upcyclers making a deck tile

About This Toolkit & Background

This Toolkit provides comprehensive guidelines for appropriate technologies for distributed plastic waste upcycling in the Global South.

What this toolkit aims to achieve

The primary objective of this document is to provide comprehensive guidelines for appropriate technologies for distributed plastic waste upcycling in the Global South. It also serves as a reference for the entire plastic upcycling process, covering raw material preparation, machine selection, procurement, installation and operational practices, particularly suited to the Nepali context of limited infrastructure and rugged natural environment.

This document presents the technical specifications and the hands-on tips and insights captured from the project P2G between 2022 to 2026.

Background

Plastic Recycling Context in the Global South

Plastic waste management in the Himalayan regions presents unique technical challenges. The remoteness of settlements and limited transport connectivity restricts centralised waste management, irregular power supply and limited skillsets in the local communities make high-tech recycling facilities unfeasible. In such conditions, community-level recycling requires machinery that is not only effective in processing plastic waste but also reflects local skill levels, anticipated production scale, affordability, power supply and operational constraints.

Distributed Manufacturing System

Distributed manufacturing (DM) is technology, systems and strategies that change the economics and organisation of manufacturing, particularly with regard to location and scale (Durach et al., 2017). DM involves producing components at separate physical locations and coordinating the supply chain to integrate them into the final product which is close to its end users (Srai et al., 2016). Manufacturing in the Global South has grown rapidly, with value-added manufacturing output increasing threefold in sub-Saharan Africa and sevenfold in South Asia between 1990 and 2020 (World Bank, 2021). Although not the largest contributor to greenhouse gas emissions, according to the World Resources Institute, industries have shown the fastest cumulative growth in emissions rising by 187% since 1990 (Ge et al., 2020).

Distributed Manufacturing for Circular Economy

Distributed Manufacturing Systems (DMS) represent a new localised form of production that decentralises manufacturing into smaller, flexible units closer to end-users (Srai et al., 2016; Durach et al., 2017). DMS, enabled by emerging technologies, reshapes production by reducing energy use, costs, and environmental impacts while enhancing adaptability and responsiveness (Durach et al., 2017; Srai et al., 2020; Gupta et al., 2021). Recent trends such as value chain decentralisation, demand for customised products, and open innovation further drive this shift (Srai et al., 2016; Deloitte, 2015). However, most DMS research focuses on high-tech applications, with limited exploration of its potential in recycling and circular economy contexts, where low-tech, community-based solutions could offer significant impact.

DMS Potential for Nepal's Plastic Circularity

In Nepal, the DMS remains a nascent concept in waste management, yet it holds significant potential to address systemic inefficiencies. In Nepal, the informal sector composed of waste pickers and small-scale recyclers plays a crucial role in handling recyclables but continues to lack proper recognition

and support (Khanal et al., 2021). Current recycling industries in Nepal are concentrated in urban areas which are difficult to operate or replicate in remote areas. Although new plastic recycling factories have recently been established, they too depend on large-scale, advanced technologies that are unsuitable for decentralised and community-level recycling. The lack of modern yet context-appropriate facilities limit the country's overall recycling potential, leaving rural and remote regions without access to sustainable waste management solutions.

By decentralising recycling processes, empowering local communities, and enhancing resource recovery, DMS offers a promising alternative tailored to Nepal's unique geographical and infrastructural challenges. Despite these obstacles, Nepal holds strong potential for resource valorisation, rooted in long-standing cultural practices of reuse and recycling within communities (Dangi et al., 2023).

Appropriate Technology

The condition of rural and remote Himalayan regions make it difficult to establish recycling facilities that are technically, economically, and environmentally viable. It is essential to assess and adopt location-specific appropriate technologies for DMS, ultimately establishing a localised circular economy (CE). In such contexts, "appropriate technology" becomes critical: solutions that are affordable, robust, and compatible with community capacities. A technology is considered "appropriate" when it can be realistically adopted, operated, maintained, and scaled by the community itself, enabling effective waste management, sustained operations, and livelihood opportunities without heavy reliance on external expertise.

For P2G, machine selection was guided by principles of mobility, affordability, power compatibility, durability, and ease of maintenance, while ensuring inclusivity through user-friendly designs so women, elderly individuals, and other GEDSI (Gender Equality, Disability and Social Inclusion) groups could participate meaningfully. Choices were aligned with local skill levels, available power supply, and anticipated production scale to match community capabilities.

A central concern is how to engage the local communities where formal waste management is unable to reach. Therefore, combining community-driven approaches with appropriate technologies for waste management is essential to create a mutually beneficial solution.

GD Labs piloting Poly+ Roll in the workers' room

1.
Raw Material Handling

Following the setup of the plastic recycling room and the installation of all the required machines, we started the procurement of raw materials for testing the machines and starting the prototyping.

1.1 Types of Raw Material

Primarily there are three types of raw materials that the recycling machine can process.

Crushed Plastics

Crushed plastics are the largest form of plastics that is smaller than the actual size of the product. These types of plastics range from 10 cm to 30 cm and some are much larger in size. For our specific purpose we sourced these plastics from Doko Recyclers.

Shredded Plastics

The crushed plastics or plastics of which were cut from the waste plastic products are further processed using the shredder machine. The shredding machine that we house in our recycling facility can shred the plastics to a size of about 10 mm. This size is controlled by the size of the hole punched into the sieve which is placed right below the blades of the shredder.

Pellets

Nurdles, commonly known as plastic pellets or plastic beads, are widely used as the raw materials to produce any plastic products. These plastic pellets can also be made from recycled plastic. Currently, the FabLab recycling facility does not have the equipment required to produce plastic pellets in-house. Hence, we source this material from within Kathmandu Valley. Typically these pellets are smaller than 5 mm in size and resemble small beads.

Figure 1
Crushed Plastics

Figure 2
Drying out crushed plastics after washing

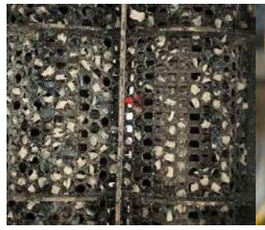

Figure 3
Sieve holes underneath the blades

Figure 4
Shredded plastic

Figure 5
White coloured plastic pellets

Figure 6
Blue coloured plastic pellets

1.2 Challenges

The major challenges that we faced during the procurement and processing of raw materials for plastic recycling are briefly described below.

Adequately Clean Plastics

Apart from the pellets, most of the plastics we bought or were sourced from other people were mixed with other wastes, mostly papers, other plastics, mud, oil, cleaning detergent etc, this was evident as they were wastes. Hence they had to be cleaned and pre-processed before they could be fed into the shredder machine.

Variety of Plastics and Reliable Vendor

There are very few vendors, in the formal sector, who deal with plastic wastes. Actors such as Doko Recyclers handle only certain plastic types; for instance, they were unable to supply LDPE (Low Density Polyethylene). (Low Density Polyethylene). Additionally, for pellet procurement it was difficult to get hold of a reliable vendor.

Material not meeting the standard specification

During our sourcing from a company from Chandragiri, we found out that though the vendor identified the plastic as HDPE; however, its physical properties did not match those of standard HDPE.. The temperature at which HDPE melts is in the range of 120-130 degrees Celsius. However, while doing temperature tests from soldering rods TS-100, the material did not melt at that temperature. While recycling it using a heat press, 180-200 degrees Celsius was needed for it to form.

Difficulty Sourcing Materials Classified as Non-Recyclable, such as MLP (Multi-Layered Plastic)

MLP is widely classified as non recyclable in Nepal; consequently, it is not collected or segregated and goes directly to landfill. Hence to test the MLP sheets, we either have to collect it ourselves or it will take time to collect after the order as it is a discarded type compared to other types of waste.

Cost of the raw materials

The cost of the raw materials is fluctuating and is dependent on the Indian Market. The pellets that are made from the recycled materials are dependent on the virgin pellets that are imported from India. Hence it is hard to find the fixed price for the product that is to be developed by our entrepreneurs unless they are collectors or they have a very reliable source which is very hard to find.

Industrial Level Waste

The industrial level waste output is enormous and they are not willing to hand out their waste in small quantities to SMEs as their processing capacity is low in comparison to larger waste processing plants. Large industries are reluctant to take the hassle of sourcing out their waste to many SMEs and instead opt to source it in bulk quantities to large processing plants.

1.3 Recommendations

- Build a reliable ecosystem with collectors and pre-processors so that you maintain good control over the quality of the materials received and reliable supply chain
- Another way of tackling the issue with quality and sourcing of the raw material is to have your own small system from the waste to product. This is what we have been practicing in the remote and isolated areas where you have good control over collection, cleanliness and pre-processing.
- Inspection on type and cleanliness of the material which is used by pre processors to make pellets. Training the collectors and pre-processors for the good quality recycled pellets with focusing on the importance of quality of the pellets produced.
- We might be able to get waste from the industry which is not contaminated with other waste. The challenge may be the intake capacity of the recycling company as well as the industry wanting to have a solution in one go and you cannot be selective about the waste you want to take. Though this defeats the purpose of addressing the core problem i.e. the plastic waste piling up on the streets and landfills, which is the more pressing issue in the context of Nepal, this can be a starting point for the product innovation with less risk on supply.

1.4 Lessons

- Always test materials in small quantities prior to full-scale processing, as the melting temperature of recycled material can vary significantly.
- If you are using recycled pellets, inspect the cross section. If there are holes in it, the pellets may contain air pockets. This will affect the quality of the final product. It is recommended to search and use pellets without holes.
- If you are collecting the waste yourself, thorough sorting and cleaning might be needed.
- Heat the pellets before making the final product. It will remove the moisture in the pellets.
- If you are using a single shredder to shred different types of plastics, use the new material as a buffer material for some time so that there is no mixing with the older one. It is recommended to use different coloured materials to visually judge the mixing, this will aid in obtaining the desired material without contamination.

Paramendo's shredded multi-layered plastic at Ree Plastic Hub.

2.
Machine Selection Criteria

The following criteria were developed to select the most appropriate technologies for the region's specific limitations and barriers.

How to Choose Your Machines

A structured scoring framework was applied to evaluate the machines, as shown in Table 1. This framework was designed around the specific challenges of the location and the operational capacity of local users in Ree Gaun, Nepal. Each parameter is assigned a weighting, reflecting its importance in the local context (e.g., mobility, affordability, energy efficiency). The weighting alongside the parameter has been set based on Ree Gaun. Machines are then rated on a scale of 1–3 under each parameter, with higher scores indicating stronger suitability; for instance, lower energy use, simpler operation, or lower cost as detailed in the scoring criteria table below.

The final score for each machine is calculated by multiplying the parameter score with its respective weighting and summing across all categories. Through this evaluation, machines were not only selected based on technical performance but also on their potential to involve local community members, including women and marginalised groups, in recycling activities and value creation. The matrix thus ensured that technology adoption aligned with both operational feasibility and inclusivity goals.

Table 1 *Machine Selection Criteria Matrix*

Criteria	Descriptions
Mobility	Machines must be lightweight and compact for easy transport into remote communities.
Affordability	Both initial investment and operational costs must be manageable for local communities.
Power Compatibility	Given limited access to three-phase AC in rural Nepal, machines must be energy-efficient and compatible with available power sources. High energy demand systems are unsuitable.
Appropriate Technology	Machines should be simple to operate and maintain, matching the technical capacity of village-level users. Selection prioritises ease of use, inclusivity (including women, elderly, and GEDSI groups), and alignment with local production scales. Complex systems requiring specialised skills or components are avoided.
Durability and Maintenance	Robustness and ease of repair are essential. High-tech machines are impractical in isolated regions lacking skilled operators, repair services, or spare parts. Sensitive and complex machines discourage the local community members from using them in fear of breakage.
Machine Capability	Robustness and ease of repair are essential. High-tech machines are impractical in isolated regions lacking skilled operators, repair services, or spare parts. Sensitive and complex machines discourage the local community members from using them in fear of breakage.

Table 2 *Machine Selection Scoring Board (Based on Location – Ree Gaun)*

Selected Criteria	Parameters (Weighting)	Details to Score for the Machine
Mobility	Dimension and Weight (3)	Assess if the machine can be easily transported and installed in hilly terrain; score higher for compact and lightweight designs suitable for limited road access.
Affordability	Energy Usage (2)	Note average power consumption (kW/hr); lower energy requirement scores higher due to limited electricity supply in rural areas.
	Investment Cost (3)	Compare total machine cost (purchase + installation) against local funding capacity; lower-cost options with minimal setup score higher.
Appropriate Technology	Ease of Use (3)	Evaluate if local operators can run the machine with short training; higher scores for easily operative controls.
	Complexity of Machine (3)	Rate based on operational simplicity; machines requiring fewer steps for operation score higher.
Durability and Maintenance	Robustness (3)	Assess material quality and expected lifespan; machines suitable for rugged rural conditions score higher.
	Repair and Maintenance (3)	Evaluate availability of spare parts and local technicians; score higher if maintenance can be done locally with minimal downtime.
Machine Capability	Rate of Production (2)	Note how many units can be produced per hour/day; higher rates get higher scores, balancing with energy use.
	Maximum Product Size (2)	Assess the largest product dimension the machine can handle; align with target product requirements.
	Material Type Compatibility (3)	Evaluate the range of plastic types or materials it can process (e.g., HDPE, LDPE, PP); broader compatibility scores higher.
	Precision and Consistency (3)	Assess product uniformity and surface finish; consistent output scores higher.
Total Score	**30**	Machines with higher cumulative scores are prioritised for local suitability and community adoption.

3.
Machine Overview

This section shares the detailed overview of the 12 machines we adopted for P2G in Nepal.

PRE-PROCESSING | PRIMARY PROCESSING | SECONDARY PROCESSING | FINISHING

Figure 7
3.1 Shredder

Figure 8
3.2 Grinder

Figure 9
3.3 Extruder

Figure 10
3.4 Injection Machine

Figure 11
3.5 Sheet Press (Hot and Cold)

Figure 12
3.6 T-Shirt Press

Figure 13
3.7 Polyfloss

Figure 14
3.8 Decking Machine

Figure 15
3.9 Pavement Press

Figure 16
3.10 Router

Figure 17
3.11 Planer

Figure 18
3.12 Table Saw

Figure 19
Shredder Overview

3.1 Shredder

Breaks down hard plastic waste into consistent flakes suitable for extrusion or pressing.

Category		Description
1	Installation	A lab-scale shredder (Max. 20 Kg/Hr) was installed in the Plastic Room at FabLab Nepal. It was procured from a Gujarat-based builder via the Precious Plastic marketplace, chosen for proximity to Nepal.
2	Specification	Dimension: 1205×550×1512mm Power (Watt): 3,730 Phase: Three phase Output capacity: Max 20kg/hour Output product size: 5-8mm Skill level required: Low-Skilled Recyclable plastics: Any hard plastics Input: Cleaned, segregated plastics
3	Machine Components Overview Figure 19	1 **Hopper Loader** – Entry point for feeding plastic waste. 2 **Shredder Box** – Main shredding chamber containing twin rotating shafts. 3 **Motor & Gearbox Assembly** – Provides mechanical drive at controlled torque and speed. 4 **Discharge Chute** – Outlet for shredded plastic flakes. 5 **Control Panel** – Operates power, motor, and safety systems 6 **Emergency Stop Button** – Immediately halts machine operation in case of malfunction.
4	Strength	• Capable of handling large and tough plastic items (e.g. chairs). • High throughput for processing large volumes of plastic waste. • Produces uniform flakes ideal for further processing. • Enables in-house recycling of previously moulded parts. • Essential for completing an internal recycling workflow.
5	Weakness	• Expensive and complex to fabricate. • Requires powerful motor and safety systems. • High wear on blades; maintenance and sharpening needed. • Safety risks if not properly enclosed and used with PPE. • Sourcing replacements may be difficult in remote areas.
6	Recommendation	• Essential to establish a complete recycling setup from raw plastic waste feedstock. • Ensure robust fabrication with a powerful motor and safety enclosure. • Avoid thin plastics (e.g. LDPE sheets, MLPs) that may jam or damage the teeth. • Use magnetic segregation to remove metal contaminants before shredding. • Conduct regular blade maintenance and tighten bolts to manage vibration. • Pre-source spare parts, especially in remote setups. • Always use PPE: earmuffs, safety glasses, PM2.5-rated mask, and cut-resistant gloves.

Category		Description
7 Shredder Operating Steps	**Step 1** Ensure Cleanliness and Clear Workspace	• Before starting the machine, inspect the workspace and remove any loose materials, debris, or tools near the shredder. • Ensure the floor area is dry, stable, and non-slippery. • Confirm that the power supply (415V, 3-phase) is safely connected and all cables are properly insulated. • Keep the hopper area and output chute free from previous residue or blockage. • Make sure the safety covers and hopper guard are properly in place.
	Step 2 Pre-Operation Checks	• Verify all electrical connections are tight and properly grounded. • Ensure the MCB and motor protection board are in good condition. • Check that gearbox oil level is adequate and leak-free. • Confirm hopper guards and coupling covers are closed and locked. • Test the emergency stop switch functionality. • Ensure the output bin is empty and positioned correctly.
	Step 3 Power On the Machine Figure 20	• Switch ON the main circuit breaker from the control panel. • Press the power switch, forward button to activate the 5 HP motor. • Observe the indicator lights; a steady light indicates normal function. • Allow the machine to idle for a few seconds to confirm proper shaft rotation. • Ensure that the rotation direction matches the desired shredding flow.
	Step 4 Loading the Material Figure 21, 22	• Gradually feed clean and dry plastic waste into the hopper. • Avoid overfilling; maintain a consistent feed rate for optimal shredding performance. • Never insert hands or tools into the hopper during operation. • Use a push rod or feed tool if needed for bulky plastics, or use reverse button. • The shredded output will discharge through the lower chute.
	Step 5 Monitoring the Shredding Operation	• Observe the machine sound and motor vibration; any irregularities may indicate blockages or overloading. • Avoid continuous operation beyond 2–3 hours without a cooling interval. • Regularly check the discharge chute for accumulation or clogging. • Ensure shredded flakes are uniform and free-flowing. • If abnormal noise or jamming occurs, immediately press the emergency stop and clear the chamber once fully stopped.
	Step 6 Power Off the Machine Figure 20	• Turn OFF the motor from the control panel. • Allow the shafts to stop completely before opening any part of the shredder box. • Switch OFF the main power supply. • Disconnect from the power source during cleaning or maintenance.
	Step 7 Cleaning and Maintenance	• Always disconnect the power before cleaning. • Use a brush or vacuum to clean the hopper, shredder box, and discharge chute. • Remove any plastic residues from the cutting blades using non-metallic tools. • Check and tighten all bolts and bearings weekly. • Lubricate shafts and moving joints monthly. • Replace gearbox oil every 6 months. • Periodically inspect electrical components and wiring insulation.

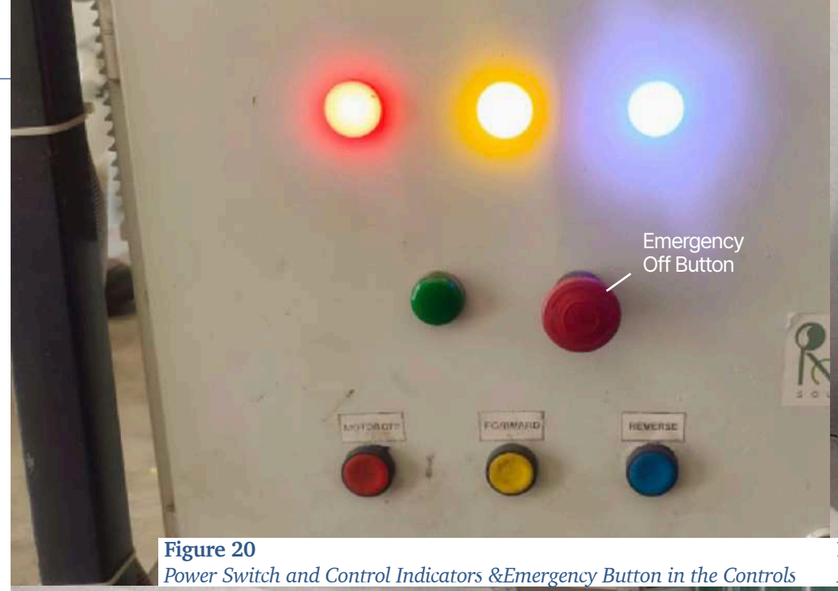

Figure 20
Power Switch and Control Indicators &Emergency Button in the Controls

Figure 21
Feeding Material into the Hopper

Figure 22
Feeding Material into the Hopper

Category		Description
7 Shredder Operating Steps	**Step 8** Safety Precautions	• Only trained personnel should operate the shredder. • Always wear industrial gloves, safety goggles, and ear protection. • Never place hands or tools near rotating shafts. • Do not overload or feed wet, metallic, or non-plastic materials. • Keep the area clear of flammable materials. • Maintain a safe distance from the discharge chute. • Test the emergency stop button daily before use.
	Step 9 Final Inspection and Storage	• Ensure the machine is clean and free from material residue. • Inspect blades and shafts for wear and replace if necessary. • Cover the machine to protect from dust and moisture. • Store in a dry, ventilated area with power disconnected. • Log operation and maintenance details for record-keeping.

Figure 23
Grinder Overview

3.2 Grinder

Breaks down soft and hard plastic waste, including thin materials such as LDPE and MLP, into fine, uniform flakes suitable for extrusion or pressing, and serves as a practical alternative to the shredder that also supports recycling of moulded parts.

Category		Description
1	Installation	Installed at the P2G Paramendo Rural Hub in Ree Gaun and the P2G KleanIt Upcyclers Urban Hub in Dang.
2	Specification	Dimension: 585×510×16mm Power (Watt): 3,730 Phase: Three phase Output capacity: 40-80 kg/hour Output product size: 6-10mm Skill level required: Low-Skilled Recyclable plastics: PP, HDPE, LDPE, MLP Input: Cleaned, segregated plastics
3	Machine Components Overview (Figure 23)	1 **Feeding Hopper** – Input section for loading plastic waste. 2 **Grinding Chamber** – Encloses blades and rotors for shredding. 3 **Blades Assembly** – 2 fixed and 3 rotating blades mounted on double shafts. 4 **Motor and Gear Assembly** – Provides mechanical drive and torque. 5 **Screen and Output Tray** – Determines final granule size and collects output. 6 **Control Panel** – Includes switches and motor protection system.
4	Strength	• Excellent for most plastic types, including thin plastics like LDPE and MLP. • High throughput for processing large amounts of waste plastic. • Easier to maintain than a shredder. • Produces fine, uniform granules (smaller than shredder output). • Useful for making consistent feedstock for extrusion and injection processes. • Enables recycling of previously moulded parts. • Serves as a practical alternative to the shredder.
5	Weakness	• Blade wear and noise issues. • Safety risks if not properly enclosed or operated without PPE. • Requires a powerful motor and robust safety systems.
6	Recommendation	• Use for thin plastics unsuitable for shredders; ideal for consistent feedstock. • Ensure robust motor and safety enclosure to manage noise and blade wear. • Standardised blade design (3–4 blades) simplifies replacement and inventory. • Avoid feeding metal objects; use magnetic segregation to protect blades. • Monitor vibration and regularly check bolts to prevent mechanical failure. • Always wear PPE: earmuffs, safety glasses, PM2.5-rated mask, and cut-resistant gloves.

7 Grinder Operating Steps

Category	Description	
	Step 1 Pre-Operation Checks	• Check that the workspace around the grinder is clean, organised, and dry. • Remove all debris, tools, and unnecessary materials near the machine. • Ensure proper lighting and ventilation for safe operation. • Confirm that the machine is placed on a stable, level surface. • Inspect power cables, hopper covers, and guard shields for damage before use.
	Step 2 Power On the Machine	• Turn ON the main power supply (415V, 3 Phase). • Switch on the control panel main switch. • Press the Start button to activate the motor. • Let the machine run idle for 20–30 seconds to ensure proper rotation. • Check for smooth running without unusual vibration or noise.
	Step 3 Loading the Material Figure 24	• Gradually load sorted and clean plastic waste into the hopper. • Avoid metal, glass, or non-plastic materials unless specified. • Use moderate feeding rate for stable grinding and prevent motor overload. • Utilise Auto Forward–Reverse Mode to manage heavy or stuck materials. • Collect output granules from the discharge tray or collection bin.
	Step 4 Grinding Operation Figure 25	• Once material is fed, monitor the machine's sound and vibration levels. • Do not overload; maintain a steady input flow. • Observe the output granule size (6–10 mm); adjust screen if necessary. • Use Auto Reverse mode to prevent jamming of material or blade overload. • The control system will stop automatically in case of high torque or overcurrent.
	Step 5 Power Off the Machine	• Press the Stop button to halt the motor. • Wait until the grinder blades stop completely. • Turn off the main power switch from the panel. • Disconnect the power supply before cleaning or maintenance.
	Step 6 Cleaning and Maintenance	• Always unplug before cleaning or maintenance. • Open the hopper cover and screen frame for inspection. • Use a soft brush or air blower to remove plastic residues. • Check blades regularly, sharpen or replace if dull. • Inspect rotor alignment and bolts for tightness. • Lubricate bearings and moving joints monthly. • Ensure MCB, contactors, and synchronization cards are dust-free. • Replace worn screens or coupling covers as needed.
	Step 7 Safety Precautions	• Operate only by trained personnel. • Always wear gloves, goggles, and ear protection. • Never insert hands or tools inside the hopper when machine is ON. • Do not bypass or remove the hopper cover or safety guards. • Avoid feeding wet materials or objects larger than designed size. • Ensure proper grounding and circuit protection. • Keep a fire extinguisher nearby. • Do not leave the grinder running unattended.
	Step 8 Final Inspection and Storage	• Inspect the grinder chamber, blades, and screen for cleanliness. • Ensure no material is left in the hopper or discharge chute. • Log the operational data and maintenance details. • Cover the machine when not in use to prevent dust ingress. • Store in a dry, ventilated area away from direct sunlight or moisture.

Figure 24
Power Switch and Temperature Control Interface

Figure 25
Grinding Chamber During Operation

Figure 26
Extruder Overview

3.3 Extruder

Melts plastic paste into horizontal moulding. Ideal for producing continuous filament or lumber for mid-sized projects, with higher output than manual injection methods.

Category		Description
1	Installation	Installed at FabLab Nepal's Plastic Room, KleanIt Upcyclers headquarters, and the P2G Urban Hub in Dang. Initially procured from the same Gujarat-based builder as the shredder and sheet press.
2	Specification	Dimension: 1200×1400×600mm Power (Watt): 8000 Phase: Single phase Output capacity: Max. 20 Kg/Hr extrusion Output product size: Up to 6 ft in length (Depends upon mould) Skill level required: Medium skilled Recyclable plastics: PP, HDPE, LDPE, PS Input: Pellets, shredded (<5mm)
3	Machine Components Overview Figure 26	**1 Feed Hopper** – For loading clean, dry, shredded plastic. **2 Extruder Barrel** – Heats and melts the material through multiple heating zones. **3 Screw and Gearbox Assembly** – Moves and compresses molten plastic toward the die. **4 Heating Zones** – 4 ceramic band heaters with PID control for uniform temperature. **5 Die Head** – Shapes molten plastic into desired profile or filament. **6 Control Panel** – Monitors and regulates motor speed, temperature, and safety systems. **7 Emergency Stop Switch** – Immediately cuts power in emergencies.
4	Strength	• Capable of producing continuous plastic filament or lumber for mid-sized projects. • Higher output compared to manual injection methods. • Versatile: can produce lumber of various sizes and cross-sections, or inject plastic into a die.
5	Weakness	• Complex to build. • Requires stable power and precise temperature control. • Skilled operators needed for tuning and safe operation. • Maintenance of components (screw, barrel) can be demanding.
6	Recommendation	• Suitable for mid-sized enterprises requiring versatile extrusion. • Begin heating from the barrel end toward the hopper to prevent pressure build-up. • Fully heat the machine before activating the motor. • Lubricate moulds and use a cooling bath to improve productivity. • Consider dual-head dividers for continuous operation and staggered die changes. • Maintain screw and barrel components regularly; design improvements may be needed for long-term repairability. • Never face the barrel end during operation. • Always wear PPE: heat-resistant gloves, safety goggles, VOC-rated gas mask, and body protection.
7	Safety Precautions	• Only trained operators should run the machine. • Always wear heat-resistant gloves, goggles, and safety shoes. • Never open the die or barrel cover during heating. • Do not operate with loose clothing or jewellry near rotating shafts. • Ensure proper grounding of the system. • Keep fire extinguishers and ventilation available near the extrusion area. • Use the emergency stop for any electrical or mechanical malfunction.

Category		Description
8 Extruder Operating Steps	**Step 1 Ensure Cleanliness and Clear Workspace**	• Before starting, ensure that the extrusion area is clean, free from debris, and well-ventilated. • Confirm the extruder base and power supply are stable and properly grounded. • Remove any leftover material from the hopper or barrel inlet. • Keep fire extinguishing equipment nearby as a safety precaution. • Ensure no flammable or moisture-prone materials are near the heating zones.
	Step 2 Pre-Operation Checks	• Verify electrical connections (415V, 3-phase) are secure and properly grounded. • Ensure all heating zone thermocouples are connected and functioning. • Check barrel cleanliness; remove any old plastic residues. • Inspect hopper and screw rotation direction. • Confirm PID controller settings for target temperature (based on plastic type): HDPE 180–200°C; PP 200–220°C; PET 250–270°C • Test the emergency stop and ensure safety covers are in place.
	Step 3 Power On the Machine Figure 27	• Turn ON the main power switch on the control panel. • Switch on the motor and heating zones sequentially. • Monitor the PID controllers for heating temperature progress. • Allow 20–30 minutes for the barrel to reach the target temperature. • Once the temperature stabilises, activate the screw motor through the inverter drive.
	Step 4 Feeding and Extrusion Process Figure 28, 29	• Load dry shredded plastic into the feed hopper gradually. • Avoid feeding wet or contaminated material. • The screw will convey, melt, and homogenise the material through the barrel. • Observe material flow from the die head, ensuring smooth, consistent extrusion. • Adjust speed (via frequency drive) and temperature zones as needed for uniform output. • Use a cooling table or air blower to solidify extruded profiles.
	Step 5 Monitoring the Extrusion Figure 30, 31	• Regularly check melt consistency and surface quality of extruded material. • Observe temperature readings for each heating zone; ensure stable operation. • Avoid abrupt speed changes or overfeeding. • If back pressure increases or output slows, stop feeding and inspect the hopper or screw. • Use the reverse jog function only after full stop and temperature reduction. • Remove the product when cooled
	Step 6 Power Off the Machine	• Turn off the screw motor first. • Allow the heaters to operate for an additional 5 minutes to clear remaining material. • Switch off all heating zones and let the barrel cool gradually. • Turn off the main power supply and disconnect from the source.

Figure 27
Power Switch and Temperature Control Interface

Figure 28
Plastic Feeding into Hopper and Material Flow

Figure 29
Plastic melted into the mould

Figure 30
Removing the product from the mould

Figure 31
Removing the product from the mould

Category		Description
8 Extruder Operating Steps	**Step 8 Cleaning and Maintenance**	• Clean the hopper and barrel inlet daily to avoid material buildup. • Use a purging compound or HDPE resin to clean inside the barrel when switching materials. • Inspect the screw, die head, and heaters weekly for residue or wear. • Lubricate gearbox and bearings monthly as per manufacturer guidelines. • Check and tighten electrical terminals and contactors periodically. • Replace ceramic heaters and PID sensors if temperature fluctuations are observed.
	Step 9 Final Inspection and Storage	• Inspect the extruded profiles for uniform thickness and smooth finish. • Record production data and material type used. • Clean all machine parts and disconnect power. • Cover the machine to prevent dust accumulation. • Store in a dry, shaded, and well-ventilated area.

Figure 32
Injection Machine Overview

3.4 Injection Machine

Melts plastic into paste for vertical moulding, ideal for compact, detailed items like keychains. Suitable for small-scale souvenir production.

Category		Description
1	Installation	Installed at FabLab Nepal's Plastic Room and the P2G KleanIt Upcyclers Urban Hub in Nargajung. Built domestically in collaboration with KIU, which later began local production and sales.
2	Specification	Dimension: 1400×800×650mm Power (Watt): 1500 Phase: Single phase Output capacity: 90 Output product size: Depends upon mould Skill level required: Low-Skilled Recyclable plastics: HDPE/PP/LDPE/PS Input: Pellets, shredded (<5mm) Recycled HDPE/PP/LDPE/PS Ground Scrap
3	Machine Components Overview Figure 32	1 **Hopper** – Entry point for feeding shredded plastic flakes or granules. 2 **Heating Barrel** – Contains heating elements that melt plastic material. 3 **Piston Assembly** – Manually operated to inject molten plastic into the mould. 4 **Handwheel** – Used to control injection pressure and piston movement. 5 **Nozzle** – Transfers molten plastic into the mould cavity. 6 **Control Panel** – Displays temperature and system power status.
4	Strength	• Versatile: melts plastic into a paste suitable for vertical moulding. • Low cost and simple to build. • Easy to operate with minimal training. • Good for small-scale, detailed products (e.g., keychains, small moulds). • Portable and compact design.
5	Weakness	• Labour-intensive with a low output rate. • Limited in product size and complexity. • Requires consistent manual force (unsuitable for large runs). • Unavailability of high-quality mould manufacturers in Nepal.
6	Recommendation	• Suitable for low-cost, small-scale production but limited in output and complexity. • Allow full melting before injection to ensure smooth moulding. • Add a removable nozzle and lubricate moving parts for easier maintenance. • Avoid leaving plastic in the barrel after use to reduce startup time. • Consider integrating a pneumatic or hydraulic press to reduce manual labour. • Source or develop better moulds locally to improve product quality. • Always wear PPE: heat-resistant gloves, safety goggles, and VOC-rated gas mask.
7	Safety Precautions	• Only operate the machine under trained supervision. • Always wear heat-resistant gloves, face shield, and long sleeves. • Do not exceed 300°C, as overheating can cause plastic degradation and fumes. • Keep hands away from the nozzle and mould area during injection. • Operate only in well-ventilated areas to avoid fume accumulation. • Ensure the emergency stop switch is easily accessible. • Never open the barrel while heating is active.

Category	Description	
8 Injection Machine Operating Steps	**Step 1 Ensure Cleanliness and Clear Workspace**	• Prepare a clean, dry, and well-ventilated workspace before operation. • Ensure the machine is placed on a stable surface (wall- or floor-mounted). • Check that all electrical cables and plug connections are undamaged. • Remove any leftover plastic residues from the hopper or nozzle. • Keep safety gloves, goggles, and protective gear ready.
	Step 2 Pre-Operation Checks Figure 33	• Confirm the machine is connected to the correct voltage (230V or 110V). • Check temperature sensors and heating elements for any faults. • Ensure the piston and nozzle are clean and lubricated. • Verify that the mould and spring clamp are properly aligned and secure. • Remove any moisture from plastic flakes before feeding. • Test the temperature control knob and ensure it displays accurate readings.
	Step 3 Power On the Machine	• Plug the machine into a dedicated 230V (or 110V) socket. • Turn on the main power switch and allow the heating elements to activate. • Set the desired temperature (up to 300°C) on the control panel. • Wait for approximately 7-10 minutes until the plastic reaches full melt consistency.
	Step 4 Loading the Material Figure 34	• Pour shredded or granulated plastic into the hopper. • Ensure the plastic feeds evenly into the barrel. • Avoid mixing wet or contaminated plastic, as this can cause bubbling or clogging. • If mixing colours, expect a marbled effect in the final product. • Wait until the material is fully melted inside the barrel before injection.
	Step 5 Injection Operation Figure 35	• Once the plastic is melted, ensure the mould is secured using the spring clamping system. • Slowly rotate the handwheel to lower the piston and inject molten plastic into the mould cavity. • Apply steady pressure to ensure a complete fill. • Hold the pressure for a few seconds to allow proper mould packing. • After injection, release the piston gradually. • Allow the product to cool slightly before opening the mould.
	Step 6 Removing the Product Figure 36, 37	• Carefully release the spring clamps. • Open the mould and remove the finished product using insulated gloves. • Inspect the part for uniform shape and fill quality. • Any leftover molten plastic in the barrel can be used for the next mould immediately.
	Step 7 Power Off the Machine	• Switch off the heating element and main power supply. • Allow the barrel to cool naturally for at least 15 minutes. • Disconnect the plug if the machine will not be used for an extended period. • Clean the nozzle and hopper once cooled.
	Step 8 Cleaning and Maintenance	• Always clean the barrel, nozzle, and piston after each session. • Use a nylon brush to remove solidified plastic; never use metal tools. • Lubricate the piston assembly and handwheel monthly. • Check heating element connections regularly for wear or damage. • Replace temperature sensors annually or if temperature inconsistencies occur. • Keep the mould clamping system rust-free and properly aligned.

Figure 33
Control Panel and Temperature Settings

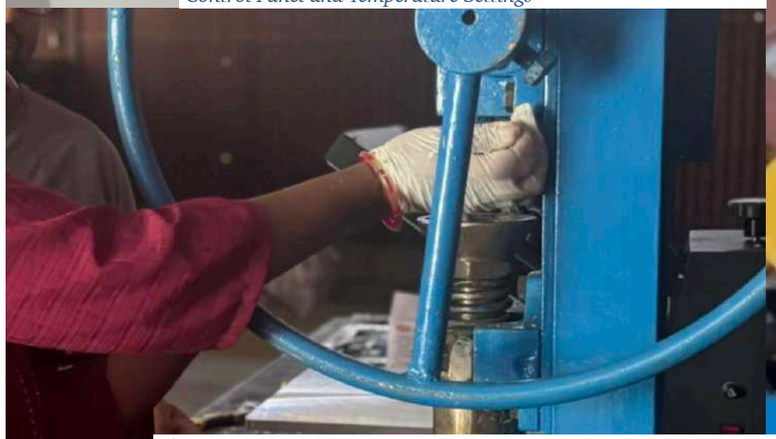

Figure 34
Loading Shredded Plastic into Hopper

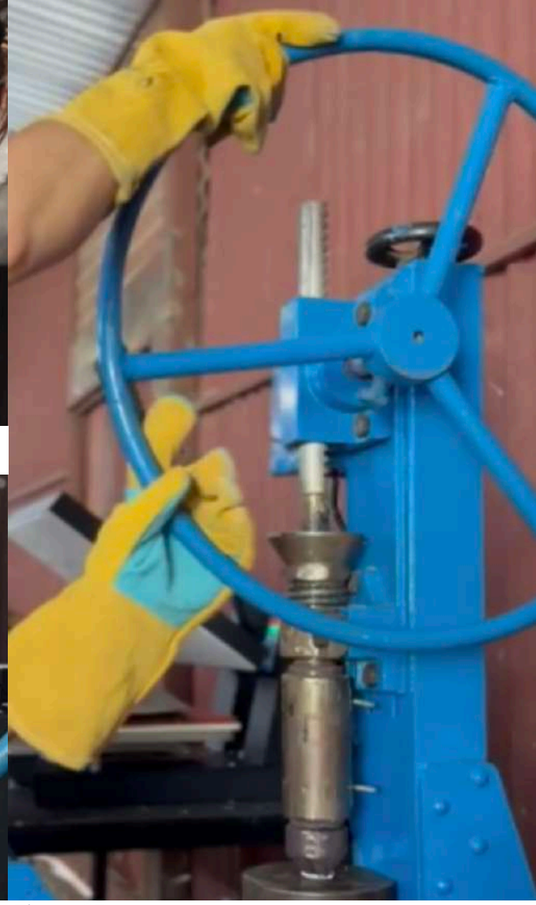

Figure 35
Manual Injection Cycle Using Handwheel and Piston

Figure 36
Opening the Mould and Removing the Product

Figure 37
Final Product

Category	Description	
8 Injection Machine Operating Steps	**Step 9 Final Inspection and Storage**	• Inspect the moulded product for uniformity and smooth finish. • Record temperature and cycle data for consistency. • Clean all components thoroughly. • Cover the machine to protect from dust. • Store in a dry, ventilated area, away from moisture and direct sunlight.

Figure 38
Sheet Press Overview

3.5 Sheet Press (Hot and Cold)

Compresses flat boards into varying thicknesses, compatible with various polymers and composites, enabling community-scale production of tiles, furniture, and other applications.

Category	Description		
1 Installation	Installed at FabLab Nepal's Plastic Room and the P2G Paramendo Rural Hub in Ree Gaun. Procured from a Gujarat-based builder via the Precious Plastic marketplace.		
2 Specification		Hot Press	Cold Press
	Dimension	8000×8000×8000mm	7000×7000×7000mm
	Power (Watt)	5000	0
	Phase	Single phase	N/A
	Output capacity	Heating time: 45 min/sheet (May vary due to plastic types)	Cooling time: 1–2 hrs
	Output product size	550mm x 550mm	550mm x 550mm
	Skill level required	Low-Skilled	Low-Skilled
	Recyclable plastics	PE, PP, ABS, MLP, TP	PE, PP, ABS, MLP, TP
	Input	Pellets or shredded (ideally <5 mm when shredded)	Output from Heat press
3 Strength	• Easy to handle for a straightforward process. • Produces flat boards of varying thickness depending on the die. • Compatible with different polymer types and pressing composites. • A medium-sized working surface enables community-scale production. • Products of uniform thickness can be produced. • Produces versatile boards for diverse applications, e.g. tiles and furniture..		
4 Weakness	• Hydraulic press can be applied unevenly • May create bubbles in the sheets (depending on the moisture content of the raw feedstock). • May stick to the mould. • High power consumption • Heavy (difficult to transport) • Risk of uneven heating if calibration fails. • Needs moulds/frames for shaping boards		
5 Recommendation	• Ensure even contact with the die before pressing to avoid uneven surfaces. • Strengthen the frame to match the hydraulic jack's force capacity. • Clean heating surfaces and guide rails regularly to prevent fumes and sticking. • Use lubricants or Teflon sheets to reduce mould adhesion. • Keep a spare temperature controller to avoid downtime. • Expect high power consumption and manage weight during transport or setup. • Always wear PPE: heat-resistant gloves, safety goggles, and VOC-rated gas mask.		
6 Safety Precautions	**Heat Press** • Always wear heat-resistant gloves and safety goggles while operating heat press. • Ensure all components, such as the hydraulic jack and PID controller, are functioning properly before each use. • Keep a fire extinguisher nearby as a precaution. **Cold Press** • Always use protective equipment such as gloves and safety glasses while operating the cold press. • Avoid placing your hands or other objects between the plates during operation. • Regularly maintain the hydraulic system and other mechanical components to ensure consistent and safe operation.		

Category	Description	
Heat Press Operating Steps	**Step 1 Ensure Cleanliness and Clear Workspace**	• Inspect the machine and its surroundings for any debris, dirt, or obstructions that might interfere with its operation. • Wipe down the heating plates and ensure that all mechanical and electrical components are clean and functional. • Confirm that the workspace is well-ventilated and free of flammable materials.
	Step 2 Prepare and Power On the Machine Figure 39, 40, 41, 42, 43	**Lower the Lower Heating Plate** • Use the hydraulic jack handle to carefully lower the lower heating plate to its starting position using the pressure release valve. **Power On the Machine** • Turn on the main switch located on the control panel. • Verify that all indicator lights are functioning and there are no error codes on the control panel. **Activate the PID Controller** • Once the main switch is turned on, the PID controllers will activate, displaying the current temperature of the heating plates. • Familiarise yourself with the layout of the controls, ensuring you know which PID controller corresponds to the upper and lower heating plates.
	Step 3 Set the Desired Temperature	• Use the control switches on the PID controller to input the desired temperature for both the upper and lower plates. • Refer to the plastic material specifications for the optimal temperature range (e.g., LDPE, HDPE, or PP). • Confirm the settings before proceeding, ensuring that both plates are synchronised for consistent heating.

Sheet Thickness	HDPE (180–200 °C)	PP (200–240 °C)
8mm	10–12 kg	12 kg
12mm	14–15 kg	14–15 kg
25mm	30–32 kg	30–31 kg

	Step 4 Preheat the Heating Plates Figure 44	• Allow the heating plates to reach the set temperature. Monitor the PID controller's display to ensure the desired temperature is attained without fluctuation. • During this time, prepare the plastic material and mould for the next steps.
	Step 5 Load the Material onto the Lower Plate Figure 45	• Place the mould onto the preheated lower plate. • Ensure the mould is centred on the plate for even pressure distribution and heating.
	Step 6 Raise the Lower Plate Figure 46	• Gradually raise the lower plate using the hydraulic jack handle. • Apply steady pressure until the handle becomes resistant, indicating sufficient pressure has been applied to compress the plastic within the mould.
	Step 7 Monitor and Maintain Compression	**Monitor and Repeat Pressing** • Observe the mould and note when the plastic begins to overflow from the edges, ensuring that the material fills the mould completely. • Lower the plate slightly (using the pressure release valve) and reapply pressure in intervals of 10-15 minutes to ensure consistent compression and even heat distribution. **Maintain Compression Time** • Depending on the type of plastic, maintain pressure for 30-45 minutes, adjusting the intervals of re-pressing as needed.

Figure 39
Hydraulic Press

Figure 40
Heat Press (Lower the lower heating plate)

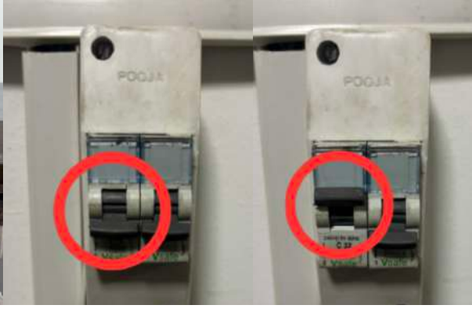

Figure 41
Switch in OFF position (left) and ON (right)

Figure 42
Currently ON, displaying current temperature

Figure 43
PID showing the set temperature

Figure 44
Layer plastic between mould and plates, add top plate

Figure 45
Place the mould on the lower plate and insert into the machine

Figure 46
Raising the lower plate using the hydraulic press

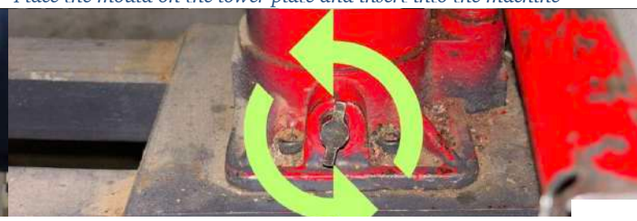

Figure 47
Rotate the pressure release valve counter-clockwise

Category	Description	
Heat Press Operating Steps	**Step 8 Power Off and Release Pressure** Figure 41, 47	**Power Off the Machine** • Once the process is complete, turn off the main switch to deactivate the machine. **Release the Hydraulic Pressure** • Slowly unscrew the release valve on the hydraulic jack to gently lower the lower plate. • Avoid sudden or abrupt release, which could cause damage or displacement of the mould.
	Step 9 Remove Mould and Final Cleanup	**Remove the Mould and Clean the Plates** • Carefully remove the mould along with the compressed material from the machine. • Put the removed mould into the cold press. (see the Cold Press manual below). **Final Inspection and Cleanup** • Inspect the compressed material to ensure it meets quality standards. • Safely store the mould and clean the surrounding area before the next operation.

Category	Description	
7.2 Cold Press Operating Steps	**Step 1 Inspect the Cold Press Machine**	• Ensure that all mechanical components of the cold press, including the hydraulic press mechanism, are functioning smoothly and without obstructions. • Check for any debris or residual material between the upper and lower plates. Clean the plates thoroughly to ensure uniform pressure distribution and avoid contamination of the final product. • Verify that the hydraulic system is free of leaks and capable of maintaining pressure.
	Step 2 Lower the Lower Plate Figure 48, 49, 50, 51	• Gradually release the pressure from the hydraulic press by turning the pressure release valve using the metal rod which has slots at one end.
	Step 3 Transfer the Heated mould Figure 52	• Carefully transfer the heated mould containing the compressed plastic from the heat press to the cold press. Use heat-resistant gloves and tools to handle the mould safely. • Position the mould precisely on the lower plate, ensuring it is centred to allow even pressure application during the pressing process.
	Step 4 Raise the Lower Plate to Press the Mould	• Use the handle of the hydraulic press to raise the lower plate slowly. • Apply pressure gradually, ensuring the mould is tightly pressed between the upper and lower plates.
	Step 5 Allow Cooling Time Figure 50, 51	• Leave the mould in the cold press for approximately 30 minutes to allow thorough cooling. • Depending on the type and thickness of the plastic, the cooling duration may vary. Ensure that the mould is adequately cooled for safe removal.
	Step 6 Lower the Plate and Release Pressure Figure 53	• Slowly lower the lower plate by carefully opening the pressure release valve using the metal rod. • Avoid sudden pressure release, which can cause damage to the mould or the machine. Monitor the lowering process to ensure smooth and controlled movement.
	Step 7 Remove the Mould	• Once the heating plates are fully separated, carefully remove the mould from the cold press. • Inspect the mould and the compressed plastic product for any defects or irregularities. • Place the mould in a designated area for further processing or cooling, if necessary.
	Step 8 Final Inspection and Cleaning Figure 54, 55	• Inspect the cold press machine for any debris or residue left behind during the process. Clean the plates and surrounding areas thoroughly. • Check all hydraulic components for wear or potential maintenance needs, ensuring the machine is ready for the next operation. • Store the machine in a clean and dry environment, ensuring it is in optimal condition for future use.

Figure 48
The metal circular rod

Figure 49
The slot at the end

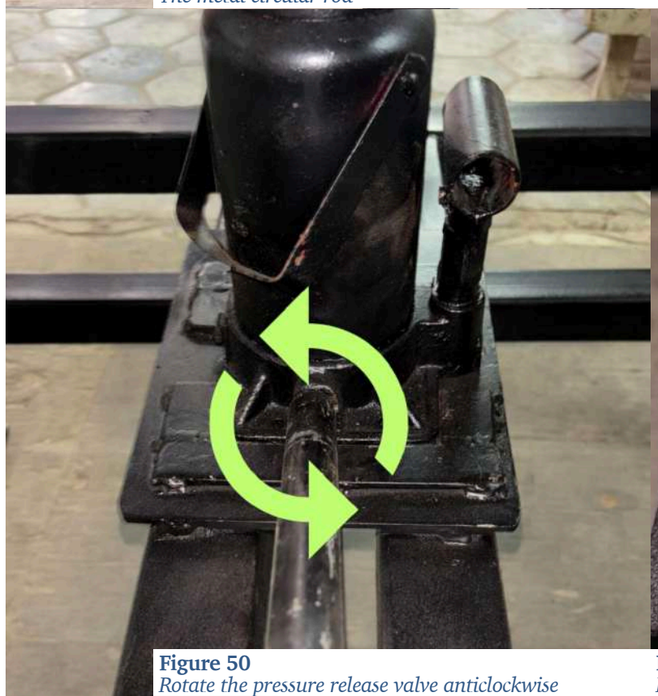

Figure 50
Rotate the pressure release valve anticlockwise

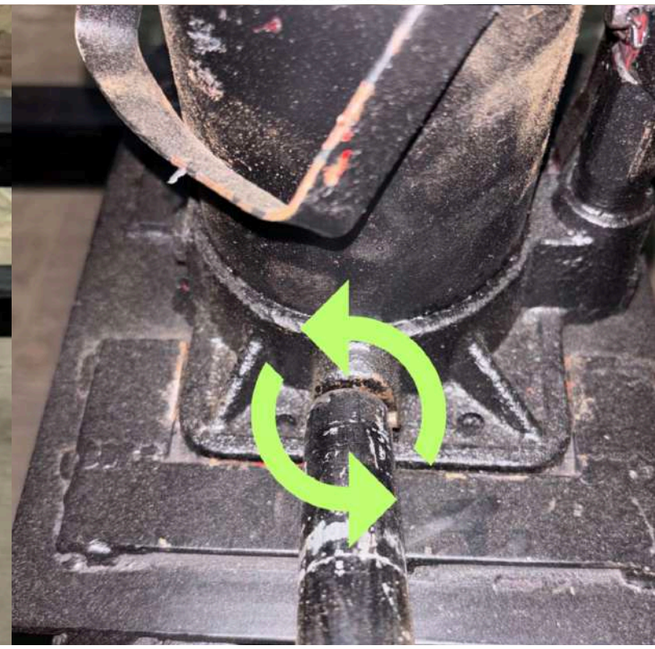

Figure 51
Rotate the pressure release valve anticlockwise

Figure 52
Transfer the mould from heat press to cold press

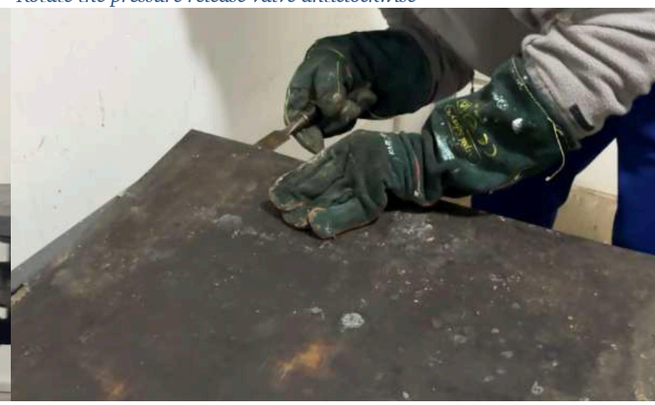

Figure 53
Remove mould and pry off upper plate with chisel or scraper

Figure 54
Remove the plastic tile carefully with a chisel or scraper

Figure 55
Final product

Figure 56
T-Shirt Press Machine Overview

3.6 T-Shirt Press

Melts thin plastic films like LDPE into flexible, waterproof sheets for applications such as roof repair and notebook covers.

Category		Description
1	Installation	Installed at FabLab Nepal's Plastic Room and the P2G Paramendo Rural Hub in Ree Gaun. Repurposed from a conventional fabric-printing press.
2	Specification	Power (Watt): 1400 Phase: Single phase Output capacity: 12-20 sec (may vary due to thickness) Output product size: 400×600mm Skill level required: Low-Skilled Recyclable plastics: PE Input: Thin-cut LDPE films
3	Machine Components Overview Figure 56	1 Handle – Used to lift and lower the upper heat plate. 2 Hot Coil Surface – Contains internal coils responsible for heating. 3 Temperature and Time Control Screen – Displays and adjusts temperature and duration. 4 Lever / Pressure Control Handle – Used to control and adjust pressure during pressing.
4	Strength	• Easy to handle and operate with basic training. • Simple production process • Lightweight and portable: can be carried and operated by one person • Effective for recycling LDPE sheets • Low-cost and locally available in Nepal • Widely available locally and relatively affordable.
5	Weakness	• Susceptible to breakage under high pressure • Uneven pressure distribution during pressing • Temperature discrepancies between the heating surface and the set value • Challenges in maintaining uniform temperature
6	Recommendation	• Ideal for small-scale or community-level LDPE recycling. • Use a die to improve uniformity, especially with flexible upper plates. • Add Teflon or silicone sheets to customise surface texture and prevent sticking. • Monitor temperature discrepancies and avoid high-pressure use to prevent breakage. • Clean surfaces regularly to maintain consistent heating and reduce fumes. • Always wear PPE: heat-resistant gloves and VOC-rated gas mask.
7	Safety Precautions	• Do not operate with wet hands, as this poses a risk of electric shock. • Always wear heat-resistant gloves and a face mask. • Avoid touching the upper heating surface during or immediately after pressing. • Use only Teflon sheets to prevent direct contact of plastic with the heat plate. • Do not exceed the recommended temperature (140°C for LDPE) to avoid melting damage. • Ensure proper ventilation during heating to avoid plastic fumes. • Keep children and untrained personnel away from the machine.

Category		Description
8 T-Shirt Press Operating Steps	**Step 1 Ensure Cleanliness and Clear Workspace**	• Confirm that the working area is clean, dry, and free of clutter. • Ensure the machine surface and surrounding area are dry before connecting to the power supply. • Place the machine on a stable, flat surface with sufficient ventilation. • Keep safety gear (gloves and face mask) ready for use. • Never operate the machine near flammable materials.
	Step 2 Pre-Operation Checks	• Verify that the power cable and plug are in good condition. • Ensure hands are dry before touching the machine. • Inspect the hot surface to confirm it is clean and free of debris. • Confirm that the Teflon sheet is clean and properly placed on the lower plate. • Set the temperature and time according to material type before pressing.
	Step 3 Power On the Machine Figure 57	• Connect the press to the main electrical supply (220V AC). • Turn on the main power switch located near the control screen. • The digital display will light up, showing the default temperature and time. Adjust the TEMP button on the right side to set the desired temperature. • Adjust the TIME button to set the required pressing duration.
	Step 4 Operation Steps for Making LDPE Sheets Figure 58, 59, 60	• Use clean and uncontaminated LDPE plastic. • Cut into appropriate pieces using scissors. • Measure 30 grams of LDPE plastic for a sheet size of approximately 20 × 30 cm. • Switch on the machine and preheat it. • Set the temperature to 140°C and time to 80 seconds. • Allow the heating plate to reach the set temperature before loading material. • Place the cut plastic between two Teflon sheets and place it centrally on the hot plate. • Lower the handle/lever to apply firm, even pressure. • Wait until the buzzer indicates completion (after 80 seconds). • Lift the handle carefully and remove the Teflon sheet using heat-resistant gloves. • Take out the pressed LDPE sheet. • Trim the edges neatly using scissors. • The LDPE sheet is now ready for use.
	Step 5 Power Off the Machine	• Once pressing is complete, switch off the power supply. • Allow the heating plate to cool naturally before cleaning. • Unplug the machine if not in use for long periods. • Clean both plates with a soft, dry cloth.
	Step 6 Cleaning and Maintenance	• Always ensure the machine is unplugged and cooled before cleaning. • Wipe the heating surface with a dry, lint-free cloth. • Inspect Teflon sheets for damage or dirt and replace if necessary. • Check power cord and connections regularly. • Do not use metal tools or sharp objects on the heat plate. • Store in a dry and dust-free environment.
	Step 7 Final Inspection and Storage	• Inspect the pressed sheet for smoothness and uniformity. • Check the machine for cleanliness and ensure all controls are turned off. • Record temperature and time settings used for future reference. • Store the T-Shirt Press in a cool, dry place covered with a dust guard.

Figure 57
Temperature and time control display

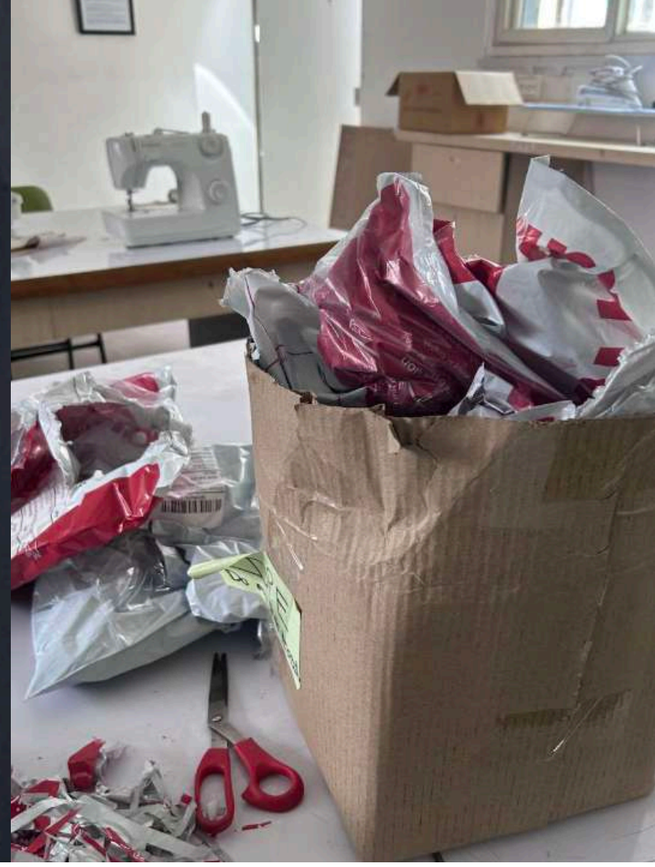

Figure 58
Collected LDPE plastics

Figure 59
Measuring LDPE plastic on digital scale

Figure 60
LDPE plastic pieces arranged on heat press plate

Figure 61
Polyfloss Overview

3.7 Polyfloss

Transforms plastic pellets and flakes into wool-like fibres for insulation, textiles, stuffing, and creative applications. Offers unique material outputs not achievable with other machines.

Category		Description
1	Installation	Installed at FabLab Nepal's Plastic Room and GD Labs. Introduced as a high-tech machine for experimental recycling.
2	Specification	Dimension: 1580×1250×2440mm Power (Watt): 7000 Phase: Single phase Output capacity: 7kg/hr (max 10 kg/hr) Output product size: Fibres Skill level required: High Skilled Recyclable plastics: PP (PET - under R&D) Input: Pellets and clean shredded (<3mm)
3	Machine Components Overview Figure 61	1 **Feed Hopper** – Entry point for shredded plastic flakes. 2 **Heating Chamber** – Melts the plastic material. 3 **Centrifugal Drum** – Spins molten plastic to form fibres. 4 **Collector Chamber** – Gathers produced fibres for cooling and packaging. 5 **Control Panel** – Regulates temperature, rotation speed, and safety settings. 6 **Emergency Stop Switch** – Immediately halts operation in case of malfunction.
4	Strength	• Creates a lightweight, insulating, and flexible material. • Adds higher value to plastic waste compared to flakes or pellets. • Offers potential for humanitarian and R&D use. • Provides a unique material output not achievable with other recycling machines.
5	Weakness	• Sensitive, high-maintenance, and lacking standardisation • Limited yield; output often needs further processing • Requires stable power and precise temperature control • Only works on PP pellets; struggles with shredded plastics • Expensive, large, and non-portable • High fume generation; hot surface safety risks • Complex to repair and maintain
6	Recommendation	• Best suited for R&D or humanitarian use due to low production rate and high cost. • Skilled operators are essential; production quality improves with slower output. • Upgrade to models that handle both PP and PET for better efficiency. • Monitor temperature and airflow closely; keep spare parts for complex repairs. • Not ideal for commercial scalability due to limited yield and high maintenance. • Always wear PPE: gas mask, earmuffs, safety glasses, heat-resistant gloves, and full-body coveralls.
7	Safety Precautions	• Operate only on a stable, level surface. • Always wear heat-resistant gloves, eye protection, and long-sleeved clothing. • Do not insert hands or tools near the drum during rotation. • Ensure adequate ventilation to dissipate fumes from melting plastics. • Keep fire extinguishing equipment nearby. • Use the emergency stop in case of mechanical or electrical faults.

Category		Description
8 Polyfloss Operating Steps	**Step 0 Understanding the Machine**	The Polyfloss Machine uses hot centrifugation (similar to candy floss making) to melt and spin shredded plastic waste into fibres (polyfloss). These fibres can be used for thermal insulation, sound insulation, textile filling, or as raw material for moulded plastic products.
	Step 1 Ensure Cleanliness and Clear Workspace	• Check that the workspace is clean, dry, and well-ventilated. • Remove any debris or dust that could interfere with airflow or heating. • Ensure that the Polyfloss Machine, centrifugal chamber, and feed hopper are free from residues. • Verify that the machine is placed on a stable, non-flammable surface with enough clearance for airflow and maintenance access.
	Step 2 Pre-Operation Checks	• Verify that all electrical connections are secure and grounded. • Inspect the heating elements and rotor for any signs of wear or residue buildup. • Ensure safety shields and covers are properly locked. • Confirm that the shredded plastic feedstock is clean and dry, free from metal or contaminants. • Check that the collection bin is properly installed.
	Step 3 Power On the Machine	• Turn the main power switch to the ON position. • Activate the heating system via the control panel. • Allow the heating chamber to reach the operating temperature (typically 180–220°C) depending on the plastic type. • Once temperature stabilisation is confirmed, activate the centrifugal motor.
	Step 4 Loading the Material Figure 62	• Slowly pour shredded plastic into the feed hopper. • Avoid overloading; feed gradually for consistent fibre output. • Monitor the temperature and rotation speed to prevent clumping or overheating. • The molten plastic will spin into fine floss fibres, which are automatically collected in the chamber.
	Step 5 Monitoring the Process	• Observe fibre formation through the viewing window. • Adjust temperature or speed if fibres appear too thick or fused. • Ensure uniform fibre production by keeping feed rate steady. • Avoid opening any access panels during operation.
	Step 6 Collecting the Floss Material Figure 63	• Once production is complete, turn off the heating system while allowing the drum to cool down. • Open the collector compartment and remove the cooled fibres. • Handle fibres with heat-resistant gloves. • Transfer the fibres to storage containers or baling units for further use.
	Step 7 Power Off the Machine	• Switch the centrifugal motor off. • Allow the chamber to cool for at least 30 minutes. • Turn off the main power switch. • Disconnect the power supply if not in use for extended periods.

Figure 62
Loading shredded plastic into feed hopper

Figure 63
Removing cooled polyfloss fibres from collector compartment

Category		Description
8 Polyfloss Operating Steps	**Step 8 Cleaning and Maintenance**	• After each batch, remove plastic residues from the heating chamber and rotor. • Clean surfaces using a soft brush and non-corrosive cleaner. • Inspect heating elements and electrical wiring weekly. • Lubricate bearings and rotating components monthly. • Replace filters and safety seals as recommended by the manufacturer.
	Step 9 Final Inspection and Storage	• Inspect the produced fibres for consistency and quality. • Clean all machine components before shutdown. • Store the machine in a dry, shaded area. • Cover the unit to prevent dust accumulation when not in use.

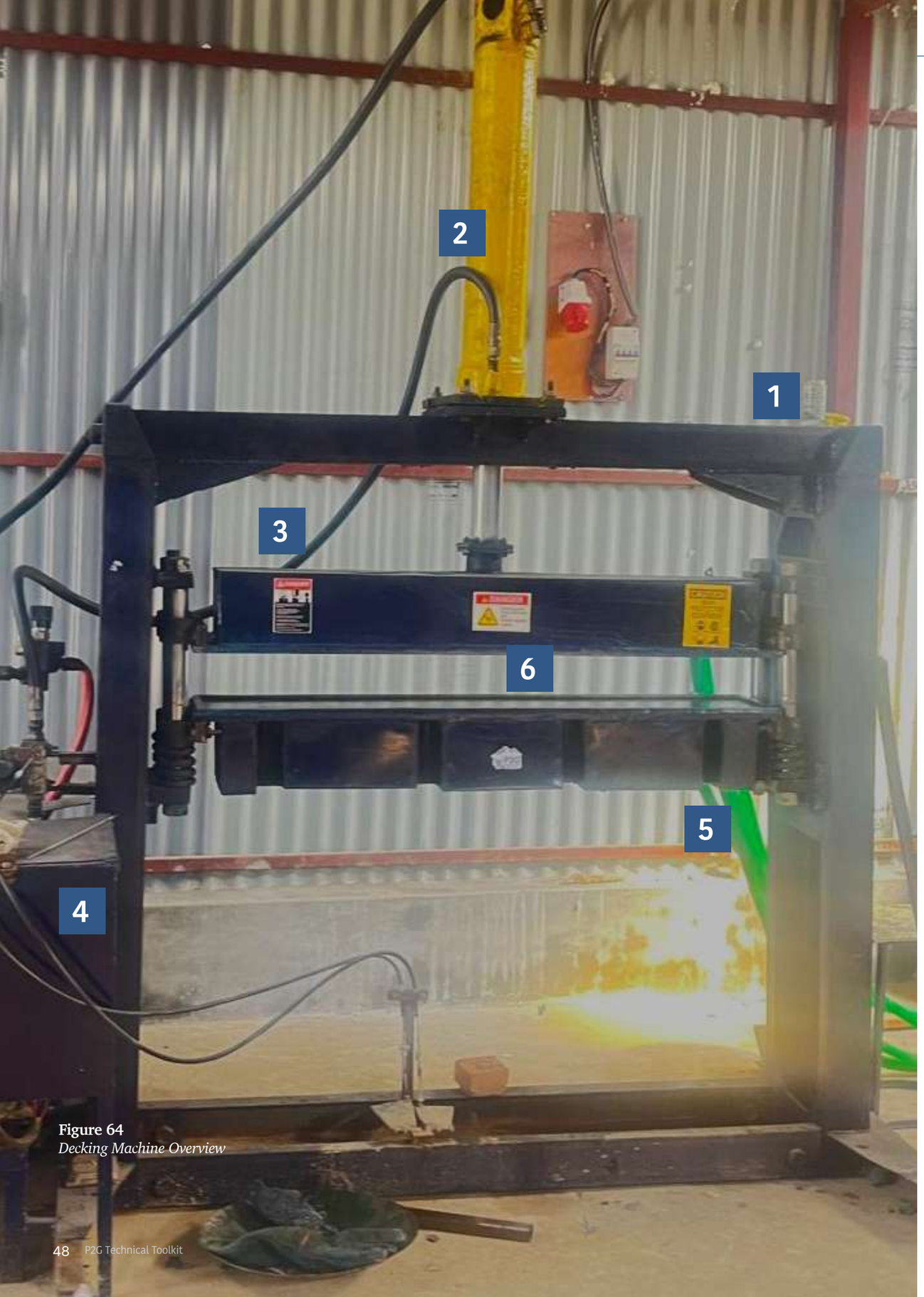

Figure 64
Decking Machine Overview

3.8 Decking Machine

Produces industrial-quality plastic decking boards. Offers high production capacity (1–2 tonnes/day) with fast cycle times (~90 seconds).

Category		Description
1	Installation	Installed at the P2G KleanIt Upcyclers Urban Hub in Nargajung. Operates in combination with an extruder.
2	Specification	Dimension: 1100×120×20mm Power (Watt): 7500 Phase: Three phase Output capacity: 200 kg/hr Output product size: 122 × 21 × 0.1 cm Skill level required: Low-Skilled Recyclable plastics: PP, HDPE, LDPE Input: Output from Extruder
3	Machine Components Overview Figure 64	1 **Main Frame** – Structural base supporting the press mechanism. 2 **Hydraulic Cylinder** – Provides pressure for compression. 3 **Heating Plate Assembly** – Applies uniform heat and pressure to mould recycled plastic. 4 **Control Panel** – Contains switches, temperature controller, and motor control. 5 **Cooling System** – Regulates machine temperature post-press. 6 **Mould Section** – Shaping area where molten plastic is compressed into decking profiles.
4	Strength	• High production capacity (1–2 tonnes/day) with fast cycle times (~90 seconds) • Easy to operate; low skill requirements • Locally manufactured; parts and repairs readily available • Interchangeable dies for varied textures and profiles • Compatible with a range of plastic types • Smooth ejection process
5	Weakness	• High initial cost. • Heavy and difficult to transport or install, especially in remote areas. • Die manufacturing is challenging in Nepal. • Locally made machines may lack precision or durability. • High-pressure operation poses safety risks if precautions are not followed.
6	Recommendation	• Best suited for mid-scale operations; not ideal for remote or mobile setups due to size and weight. • Customise textures/profiles using interchangeable dies • Training required for high-pressure operation and emergency procedures • Maintain spare cutting wheels, inspect components regularly, lubricate moving parts • Reuse off-cuts for sheet/timber production
7	Safety Precautions	• Required PPE: gas mask, earmuffs, safety goggles, heat-resistant gloves, full-body overalls • Trained personnel only • Do not bypass or disable safety interlocks • Never place hands inside mould area during pressing • Keep flammable materials away • Test emergency stop button regularly • Ensure uninterrupted cooling water circulation during extended operations

Category	Description	
8 Decking Machine Operating Steps	**Step 1 Ensure Cleanliness and Clear Workspace**	• Inspect the decking machine and the surrounding workspace to ensure cleanliness and safety. • Remove any debris, tools, or obstructions near the working area. • Ensure proper ventilation and non-slippery flooring around the machine. • Verify that the hydraulic lines, power cables, and water-cooling system are properly connected and free from leaks or visible wear.
	Step 2 Pre-Operation Checks	• Ensure all bolts, nuts, and fittings are tightened securely. • Check oil levels in the hydraulic reservoir and top up if needed. • Inspect the water-cooling lines for proper flow. • Ensure heating plates are clean and free of plastic residue. • Verify that the power connection matches the rated 220V, 3-phase supply. • Make sure the emergency stop button is functional.
	Step 3 Power On the Machine	• Turn the main power switch to the ON position. • Activate the hydraulic motor using the control panel switch. • Allow the heating system to reach the desired operating temperature (typically between 180–200°C, depending on plastic type). • Monitor the indicator lights to confirm stable temperature and hydraulic pressure.
	Step 4 Loading the Material Figure 62	• Open the press and clean the mould surface. • Place the measured quantity of shredded or molten plastic evenly into the mould cavity. • Align the upper and lower mould surfaces for uniform pressing. • Ensure no foreign materials are inside the mold before pressing.
	Step 5 Pressing Operation	• Lower the upper press plate using the hydraulic lever. • Apply pressure gradually until the indicator shows full hydraulic pressure. • Maintain pressure for the full 90-second cycle time to allow proper compression and shaping. • The water-cooling system may automatically engage to regulate temperature. • Once the cycle completes, release the hydraulic pressure slowly.
	Step 6 Removing the Product Figure 63	• Carefully raise the upper press plate using the control lever. • Remove the finished plastic decking piece using insulated gloves. • Inspect the product for uniform thickness and finish. • Place the hot product on a cooling tray or flat surface for solidification.
	Step 7 Power Off the Machine	• Turn off the heating system and hydraulic motor. • Switch off the main power supply. • Allow the system to cool naturally before performing cleaning or maintenance.
	Step 8 Cleaning and Maintenance	• Wipe the heating plates and mould with a soft, dry cloth after each use. • Drain and clean the water-cooling system weekly. • Check hydraulic oil levels regularly and replace oil every 6 months. • Lubricate moving joints and hinges monthly. • Inspect hydraulic hoses and electrical cables for wear or damage. • Replace filters and seals as per manufacturer's guidance.

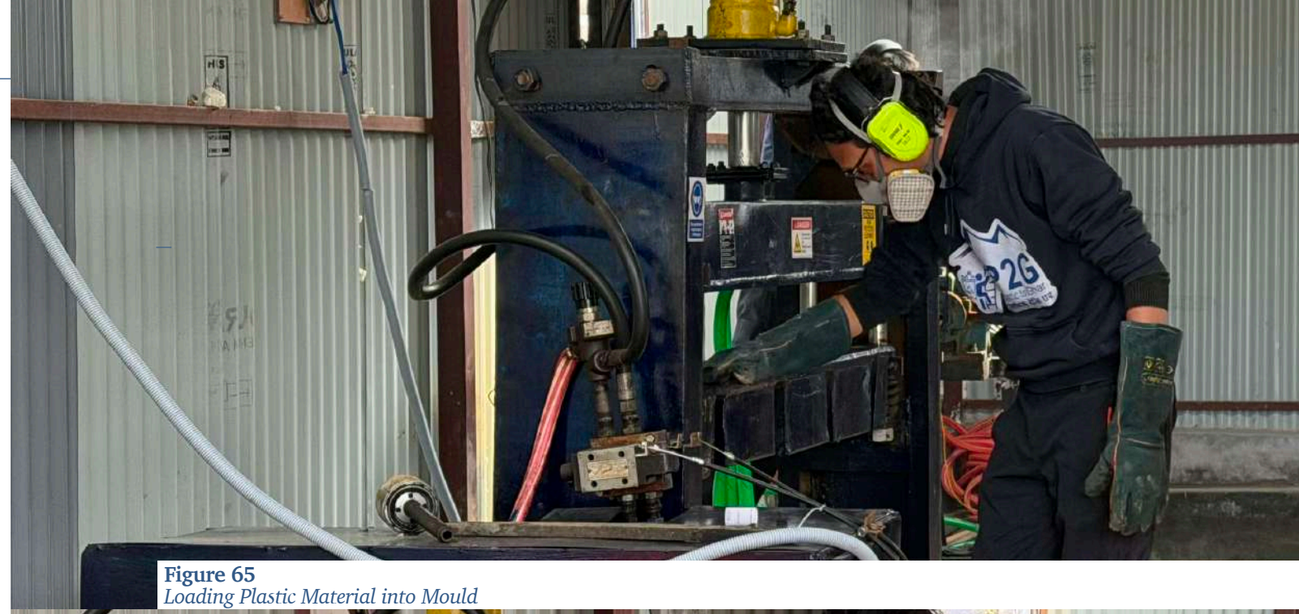

Figure 65
Loading Plastic Material into Mould

Figure 66
Pressing Operation in Progress

Figure 67
Product Removal and Cooling

Figure 68
Pavement Press Overview

3.9 Pavement Press

Compresses sand-plastic mixtures into heavy-duty pavement blocks. Offers high compression strength and consistent density, suitable for outdoor applications.

Category	Description
1 Installation	Installed at the P2G KleanIt Upcyclers Urban Hub in Dang. Operates alongside an extruder to produce pavement blocks.
2 Strength	• Large production capacity of 2–4 tonnes/day. • Easy to operate with basic training. • High compression strength ensures high consistent thickness and density. • Can be set up in semi-urban or rural areas in limited space.
3 Weakness	• Manual transfer of a high-temperature sand-plastic mixture from the extruder poses a significant safety risk and requires caution. • High initial investment cost. • Limited by mould designs. • Spares are not easily available in Nepal, leading to potential downtime. • Capacity limitation: up to 500 bricks a day.
4 Recommendation	• Best suited for mid-scale operations; not ideal for mobile or remote setups due to size and weight. • Suitable for B2G civil construction models. • Replace sand with crushed glass waste to diversify input materials. • Ensure safe handling of high-temperature mixtures during manual transfer. • Plan for high initial investment and limited mould design flexibility. • Keep spare parts in stock to avoid downtime. • Always wear PPE: gas mask, earmuffs, safety glasses, heat-resistant gloves, and full-body coveralls.

Figure 69
Router Overview

3.10 Router

Smooths the edges of plastic lumber and boards. Enhances product quality and precision, especially in post-processing.

Category		Description
1	Installation	Installed at FabLab Nepal and the P2G KleanIt Upcyclers Urban Hub in Nargajung. Used as an affordable finishing tool.
2	Specification	Dimension: 230×260×170mm Power (Watt): 1600 Phase: Single phase Output capacity: N/A Output product size: N/A Skill level required: Low-Skilled Recyclable plastics: All types of Hard Plastic Input: Hard Thick Plastic (Above 1 mm)
3	Machine Components Overview (Figure 69)	1 **Motor Housing –** Contains the electric motor that powers the router. 2 **On/Off Power Switch** – Controls router power. 3 **Collet Nut** – Secures router bit in place (commonly 6 mm–12 mm). 4 **Base Plate (Sole Plate)** – Stabilizes router on work surface during operation. 5 **Handles (Left and Right)** – Provide grip and control during operation. 6 **Power Cord and Plug** – Supplies electrical power; must be intact and grounded.
4	Strength	• Easy, quick, and low-cost finishing for high-quality results • Versatile: cuts edges, grooves, joints, and decorative patterns • Compatible with wood, plastics, and laminates; wide variety of bits available • Lightweight, portable, and operable by one person • Ideal for post-processing extruded lumber and custom or one-off work
5	Weakness	• Requires skill and steady hands for precise operation. • Safety risks: potential for kickback and bit breakage. • Generates significant dust and noise. • Limited by the user's physical control and reliance on template guides. • High RPM operation increases the risk of accidents if not handled properly.
6	Recommendation	• Ideal for low-cost edge finishing and custom work across plastics, wood, and laminates. • Use template guides and maintain steady control to avoid kickback and bit breakage. • Collect cut-off waste for reuse in sheet or lumber production. • Choose appropriate bits for grooves, joints, and decorative patterns. • Operate with care at high RPM to prevent accidents. • Always wear PPE: earmuffs, cut-resistant gloves, safety goggles, and PM2.5-rated mask or face shield.
7	Safety Precautions	• Always wear safety goggles, ear protection, and anti-slip gloves. • Do not operate the router near flammable materials or liquids. • Ensure bits are properly tightened before operation. • Avoid touching the router bit immediately after use, as it may be hot. • Keep hands clear of the rotating bit at all times. • Disconnect power before changing bits or performing maintenance.

Category		Description
8 Router Operating Steps	**Step 1 Ensure Cleanliness and Clear Workspace**	• Inspect the router and surrounding workspace for dust, plastic debris, or obstructions. • Work in a dry, stable area with good lighting and ventilation. • Ensure the router is unplugged before any setup or inspection.
	Step 2 Assemble the Router Figure 70, 71, 72	• Attach the guide holder or straight guide as required for your routing application. • Press the Unlock button below, and rotate the above drill bit clamp to insert the router bit. • Insert the router bit into the collet (6mm–12mm) and tighten securely with the provided wrenches. • Adjust the plunge depth by loosening the depth stop lever and setting the desired cutting depth (0–60mm). • Ensure all attachments are tight before operation.
	Step 3 Power On the Machine	• Plug the router into a compatible 220–240V socket. • Hold the router firmly with both hands. • Switch ON the power button located on the side handle. • Allow the router to reach full speed (22,000 RPM) before making contact with the material.
	Step 4 Routing Operation Figure 73	• Secure the plastic sheet or block firmly on the workbench using clamps. • Gently lower the router until the bit contacts the material surface. • Move the router in a clockwise direction for internal cuts and counter-clockwise for edge trimming. • Apply steady pressure and avoid forcing the router through the material. • Monitor the bit's performance; stop immediately if you notice vibration or a burning odour.
	Step 5 Adjusting Depth During Operation Figure 74	• Use the plunge lever to raise or lower the router bit for deeper cuts. • Always make multiple shallow passes rather than one deep cut to prevent motor overload and improve surface finish in the product.
	Step 6 Power Off the Machine	• Once the routing is complete, switch OFF the machine. • Wait until the bit completely stops spinning before setting the router down. • Unplug from the power source after use.
	Step 7 Cleaning and Maintenance	• Brush away any plastic debris or dust from the motor vents and base plate. • Periodically replace the carbon brushes when motor performance decreases. • Lubricate the plunge rods lightly to maintain smooth movement. • Store the router and its accessories in a clean, dry box.

Figure 70
Inserting router bit into collet

Figure 71
Adjusting the plunge

Figure 72
Adjusting the plunge

Figure 73
Routing plastic with steady pressure in proper direction

Figure 74
Making shallow passes for controlled cutting depth

Figure 75
Planer Overview

3.11 Planer

Smooths the surfaces of plastic lumber and boards. Enhances finish quality in post-processing with minimal training required.

Category		Description
1 Installation		Installed at FabLab Nepal's Plastic Room and the P2G KleanIt Upcyclers Urban Hub in Nargajung. Introduced as an affordable finishing tool.
2 Specification	Dimension	530×700×400mm
	Power (Watt)	2000
	Phase	Single phase
	Output capacity	N/A
	Output product size	N/A
	Skill level required	Low-Skilled
	Recyclable plastics	All types of Thick Plastic
	Input	Hard Thick Plastic (Above 5 mm)
3 Strength		• Easy and quick finishing touch to products. • Simple to handle and operate. • Lightweight and portable: can be carried and operated by one person. • Valuable for post-processing extruded plastic lumber to achieve a smooth finish. • Easy to operate with basic training. • Machines and replacement parts are readily available locally.
4 Weakness		• Limited to flat boards: cannot shape complex profiles. • Generates a large amount of chips and dust, requiring an extraction system. • Blades wear down over time and require sharpening or replacement. • Safety risks if proper procedures and PPE are not followed.
5 Recommendation		• Ideal for flat-surface finishing; not suitable for complex profiles. • Collect chips and dust for reuse; use an extraction system to manage waste. • Keep spare blades and inspect regularly for wear based on surface quality. • Lubricate moving parts to ensure smooth operation. • Lightweight and portable, making it suitable for small workshops. • Always wear PPE: earmuffs, cut-resistant gloves, safety goggles, and PM2.5-rated mask or face shield.
6 Safety Precautions		• Always wear safety goggles, ear protection, and a dust mask. • Keep hands and clothing away from infeed/outfeed rollers and blades. • Never remove safety covers while the machine is in operation. • Avoid planing pieces shorter than 150mm or thinner than 6mm. • Do not leave the machine running unattended. • Use only authorised accessories. • Keep children and untrained persons away from the work area.

Category		Description
7 Planer Operating Steps	**Step 1 Ensure Cleanliness and Clear Workspace**	• Confirm that the Thickness Planer and surrounding workspace are free from dust, chips, and obstructions. • Ensure the power cord, feed rollers, and blade area are clean and undamaged. • Keep the area well-lit, dry, and clear of flammable materials. • Always disconnect power before inspection, blade changes, or cleaning.
	Step 2 Assembly and Setup Figure 76	1. Place the Thickness Planer on a flat, stable workbench or stand. 2. Attach the rubber feet and secure the machine to minimise vibration. 3. Install the infeed and outfeed tables and adjust them parallel to the main bed. 4. Check that both blades are sharp and securely fitted to the cutter head. 5. Connect the dust collection port if available. 6. Verify all components are properly tightened before use. 7. Plug the machine into a grounded power source.
	Step 3 Power On the Machine	• Ensure that the power switch is in the OFF position before plugging in. • Once ready, switch it ON and allow the machine to reach full operating speed (8000 RPM). • Confirm that the rollers and cutter head are rotating smoothly without abnormal sound.
	Step 4 Material Preparation	• Ensure that the material (plastic or wood) is dry, flat, and free of metal objects. • Avoid warped or extremely thin pieces that may cause feed jams. • Mark thickness reference lines for accuracy.
	Step 5 Operating the Thickness Planer	1. Adjust the Cutting Height – Use the height adjustment winder to set the desired thickness. 2. Feed the Material – Place the material flat on the infeed table, ensuring even pressure. 3. Start Planing – 4. Feed the material steadily into the rollers. 5. Do not push or pull forcefully; let the rollers carry the piece through. 6. Support the material exiting from the outfeed side to prevent dropping. 7. Multiple Passes – For thicker materials, remove small layers (max 3mm per pass). 8. Check Thickness – Measure and repeat until the desired thickness is achieved. • Note: For plastic planing, ensure that the material is not brittle. Adjust the feed rate to prevent melting or surface marks.
	Step 6 Power Off the Machine	• Turn the switch to the OFF position after completion. • Wait until the cutter head comes to a complete stop before touching the material or making adjustments. • Disconnect from power when not in use.

Figure 76
Front view of the planer

Category		Description
7 Planer Operating Steps	**Step 7 Cleaning and Maintenance**	• After use, clean the feed rollers, table surface, and cutter head with a soft brush. • Never use water or solvents. • Apply a light coat of oil to the table surface to prevent rust. • Inspect blades regularly for sharpness and replace if dull or chipped. • Check carbon brushes and belt tension periodically. • Lubricate the height adjustment screw occasionally for smooth operation.
	Step 8 Final Inspection and Storage	• Inspect the planed materials for even surface and correct thickness. • Clean the machine thoroughly after each use. • Store in a dry, dust-free area and cover when not in operation. • Keep accessories (wrench, gauge, brushes) safely stored.

Figure 77
Table Saw Overview

3.12 Table Saw

Cuts plastic lumber and boards to size. Offers high accuracy for straight cuts and improves production efficiency and product quality.

Category		Description
1	Installation	Installed at FabLab Nepal's Plastic Room, the P2G Paramendo Rural Hub in Ree Gaun, and the P2G KleanIt Upcyclers Urban Hub in Nargajung.
2	Specification	Dimension: 430×638mm Power (Watt): 1500 Phase: Single phase Output capacity: N/A Output product size: N/A Skill level required: Low-Skilled Recyclable plastics: All types of Thick Plastic Input: Hard Thick Plastic (Above 0.5 mm)
3	Machine Components Overview (Figure 77)	1 **Saw Blade** – Circular blade for cutting rigid plastic sheets. 2 **Table Top** – Flat surface supporting material for accurate, straight cuts. 3 **Rip Fence** – Adjustable guide for consistent cutting width. 4 **Fence Lock Handle** – Secures the rip fence during operation. 5 **Height Adjustment Wheel** – Raises or lowers blade to required height. 6 **On/Off Switch** – Power control with safety cover for quick shutdown. 7 **Dust Collection Bag / Port** – Collects plastic dust and chips for clean workspace.
4	Strength	• Easy and quick finishing touch to products • Excellent for straight cuts and ripping boards. • High accuracy with proper setup (fence, guides). • Versatile, widely available locally, and relatively affordable. • Easy to operate with basic training. • Lightweight and portable.
5	Weakness	• High safety risks: exposed high-RPM blades can cause kickback or serious injury. • Limited to straight cuts: unsuitable for curves or complex shapes. • Requires ample space for handling large stock. • Blades dull quickly with heavy use and need regular replacement.
6	Recommendation	• Ideal for straight cuts; not suitable for curves or complex shapes. • Maintain ample workspace for handling large stock. • Keep spare cutting wheels and inspect blades regularly for wear. • Collect off-cuts for reuse in sheet or lumber production. • Never remove the safety cover; proper training is essential to prevent kickback and injury. • Always wear PPE: earmuffs, cut-resistant gloves, safety goggles, and PM2.5-rated mask or face shield.
7	Safety Precautions	• Always wear safety goggles, ear protection, and dust mask during operation. • Never operate the saw without the blade guard in place. • Keep hands and fingers away from the blade at all times. • Avoid loose clothing, jewellry, or long hair near moving parts. • Never leave the machine running unattended. • Ensure proper grounding of the machine before use. • Keep a fire extinguisher nearby as a precaution.

Category		Description
7 Table Saw Operating Steps	**Step 1 Ensure Cleanliness and Clear Workspace**	• Inspect the table saw and surrounding workspace for dust, debris, or obstructions. • Confirm that the blade, table surface, and power cord are clean and undamaged. • Ensure that the work area is well-lit, dry, and free of flammable materials. • Unplug the machine before making any adjustments or inspections.
	Step 2 Assembly and Setup Figure 78, 79	1. Place the table saw on a flat and stable surface. 2. Attach the rip fence and miter gauge to their respective slots. 3. Ensure the saw blade is correctly mounted, with the teeth facing forward (toward the operator). 4. Tighten the arbor nut securely using the wrench. 5. Adjust the blade guard so it fully covers the blade when not in use. 6. Confirm all components are secure before plugging in the machine.
	Step 3 Power On the Machine Figure 80	• Plug the machine into a 220–240V power outlet. • Locate the main switch and turn it to the ON position. • Wait for the blade to reach full speed (4500 RPM) before cutting any material. • Check for any abnormal vibration or noise before operation.
	Step 4 Material Preparation	• Ensure that the plastic sheet or block is free from moisture, nails, or other foreign materials. • Mark cutting lines clearly for precision. • Use clamps or guides to hold the material firmly in place, if necessary.
	Step 5 Operating the Table Saw	1. Adjust the Cutting Height – Raise or lower the blade to match the thickness of the plastic sheet, ensuring that only 5–10mm of the blade extends above the material. 2. Set the Fence or Miter Gauge – Align the fence parallel to the blade for straight cuts, or use the miter gauge for angled cuts. 3. Position the Material – Place the material flat against the table and fence. 4. Make the Cut – • Stand slightly to the side of the cutting path (never directly behind the blade). • Use a push stick for narrow pieces. • Feed the material steadily through the blade; avoid forcing it. • Maintain firm control until the material has fully passed through the blade. 5. For Angled Cuts – Tilt the blade to the desired angle (0°–45°) and adjust the fence or miter accordingly.
	Step 6 Power Off the Machine Figure 81	• After cutting, turn the switch to the OFF position. • Wait until the blade comes to a complete stop before removing cut pieces or making any adjustments. • Unplug the machine when not in use.

Figure 78
Placing the table saw

Figure 79
Attaching the rip fence and miter gauge

Figure 80
Plugging the machine

Figure 81
Result of cutting

Category		Description
8 Table Saw Operating Steps	**Step 7 Cleaning and Maintenance**	• Use a brush or dry cloth to clean the table surface, blade area, and motor vents. • Do not use water or solvents for cleaning. • Periodically check the blade sharpness and replace it if dull or damaged. • Ensure the rip fence, miter gauge, and tilt mechanism move smoothly. • Lubricate moving parts lightly as needed. • Inspect the power cord and switch regularly for wear.
	Step 8 Final Inspection and Storage	• Inspect cut materials for smoothness and accuracy. • Clean all debris from the table surface and undercarriage. • Store the blade wrench, push stick, and miter gauge in a designated area. • Unplug and cover the table saw to prevent dust accumulation.

4.
Machine Procurement & Installation

After completing the machine selection, the factors below were considered to determine the best procurement and delivery method for the desired locations.

4.1 Machine Order

It is recommended to source machines locally whenever possible, due to the following advantages:

1. **Reduced Costs**: Local procurement eliminates customs duties and significantly lowers logistics expenses.
1. **Shorter Delivery Timelines**: The proximity between the supplier and destination reduces transportation time.
1. **Lower Risk of Damage**: Shorter transit distances minimise the likelihood of damage during delivery.
1. **Improved After-Sales Support**: Local suppliers can provide faster and more reliable after-sales services.
1. **Ease of Maintenance**: Troubleshooting and maintenance can be managed more efficiently through local technical support.
1. **Enhanced Self-Reliance**: Local sourcing fosters self-dependence and reduces reliance on imports.

However, when the required machinery is not available locally, it must be imported from the nearest possible source. As a landlocked country without direct sea access, Nepal can only import via air or land routes. In this context, India and China serve as the most feasible neighboring sources for machinery importation [Table 1]. When ordering a machine, the first step is to determine whether the machine is **pre-manufactured** (ready-made) or **custom-built**.

- In the case of a ready-made machine, the process is relatively straightforward, involving only packaging and dispatch once the advance payment has been made.
- However, if the machine requires manufacturing, it is important to account for the **production lead time**.

Although manufacturers often provide estimated timelines for production and dispatch, it is advisable to allocate an **additional buffer period** of one week to one month to accommodate unforeseen delays.
Another critical consideration during importation is identifying the correct **Harmonised System (HS) Code**. The HS Code determines the applicable tariff and duty rates. It is recommended to verify these rates in advance or to consult with the importer or customs agent for clarity.

The cost that breakdown while importing the machines via land or air are:

1. Machine cost
2. Freight cost
3. Duty cost (import duty, excise duty and VAT whichever is applicable)
4. Clearing charge
5. Misc charges from import companies.

Importation Timeline via Land

The general timeline for importing machines by land includes the following stages:

1. Order placement and advance payment transfer through the banking process
2. Machine manufacturing period (if applicable)
3. Packaging and preparation for shipment
4. Transportation from the source to the border
5. Customs clearance at the border
6. Delivery from the border to the final facility

Among these, steps 1, 4, 5, and 6 are typically managed by the importing company, while steps 2 and 3 are handled by the manufacturer.
Effective coordination and communication between the manufacturer and the importing company are essential to ensure a smooth and timely importation process.

Table 3 *Analysis of machine import options*

Aspect	Import via Land (from China/India)	Import via Air (from China/India)
Speed	Moderate: depends on border traffic and customs clearance at checkpoints like Tatopani, Rasuwagadhi (China) or Birgunj, Bhairahawa (India)	Very fast: goods arrive within hours or a day via Tribhuvan International Airport
Cost	Lower transportation cost: ideal for bulk or heavy goods	Expensive freight and handling charges
Accessibility	Easy access from India (multiple land borders); Moderate access from China (limited routes and weather-dependent passes)	Limited to Kathmandu and a few airports with customs clearance
Capacity	Suitable for large, heavy, or bulky shipments like machinery, building materials, etc.	Restricted by aircraft cargo limits: better for light or high-value items
Reliability	Subject to road conditions, strikes, landslides, or customs delays	Reliable schedules: fewer disruptions once cargo is airborne
Environmental Impact	Lower carbon emissions per ton compared to air	High emissions: air freight contributes significantly to carbon footprint
Customs & Handling	Border delays common, especially at Tatopani and Birgunj; paperwork can be time-consuming	Faster customs clearance for documented shipments
Damage Risk	Higher due to road conditions and manual loading/unloading	Lower: handled carefully at airports
Weather Dependency	China routes often affected by snow or landslides; Indian routes usually stable	Possible flight delays during heavy rain or fog seasons
Flexibility	Good for mixed cargo, partial loads, or frequent small shipments	Not ideal for small, low-value shipments due to high cost
Best For	Imports of raw materials, industrial goods, consumer products in bulk	High-value, time-sensitive, or fragile goods (electronics, medical supplies, spare parts)

Importation Timeline via Air

For air flight, the process generally follows these stages:

1. Order placement and advance payment transfer through the banking process
2. Machine manufacturing period (if applicable)
3. Packaging and preparation for shipment
4. Delivery to the airport of departure
5. Air transport to the destination country
6. Customs clearance at the airport
7. Final delivery from the airport (e.g., Tribhuvan International Airport, Kathmandu) to the facility

Compared to land transport, **air importation** is faster and generally more reliable. However, it also has **limitations**, such as higher freight costs and weight or size restrictions as mentioned above.

Recommendations

Maintain continuous follow-up with both the manufacturer and the importing company to ensure timely delivery.

Always plan for a buffer period of at least a few weeks to a month to mitigate risks of unforeseen delays.

Avoid placing last-minute orders with strict deadlines, as such situations often lead to logistical challenges and increased costs.

4.2 Plastic Room Setup

While the machines had been selected, confirmed and were being shipped, we concurrently designed and constructed the plastic room. The first step was to design the layout of the room using the data, i.e., dimensions of the confirmed machine. This was done in a CAD modeling software.

The initially planned layout in Fablab Nepal is shown in Figure 1. The yellow boxes represent the overall size of the machine whereas the red boxes represent the minimum space required for working around the machine. After much discussion within the team and proper usage of the available space, the layout was further iterated and the construction began in August 2022 and ended in September 2022.

The numbers in the bubble represent the proposed location of each machine.

1. Heat Press
2. Cold Press
3. Extruder
4. Polyfloss
5. Shredder

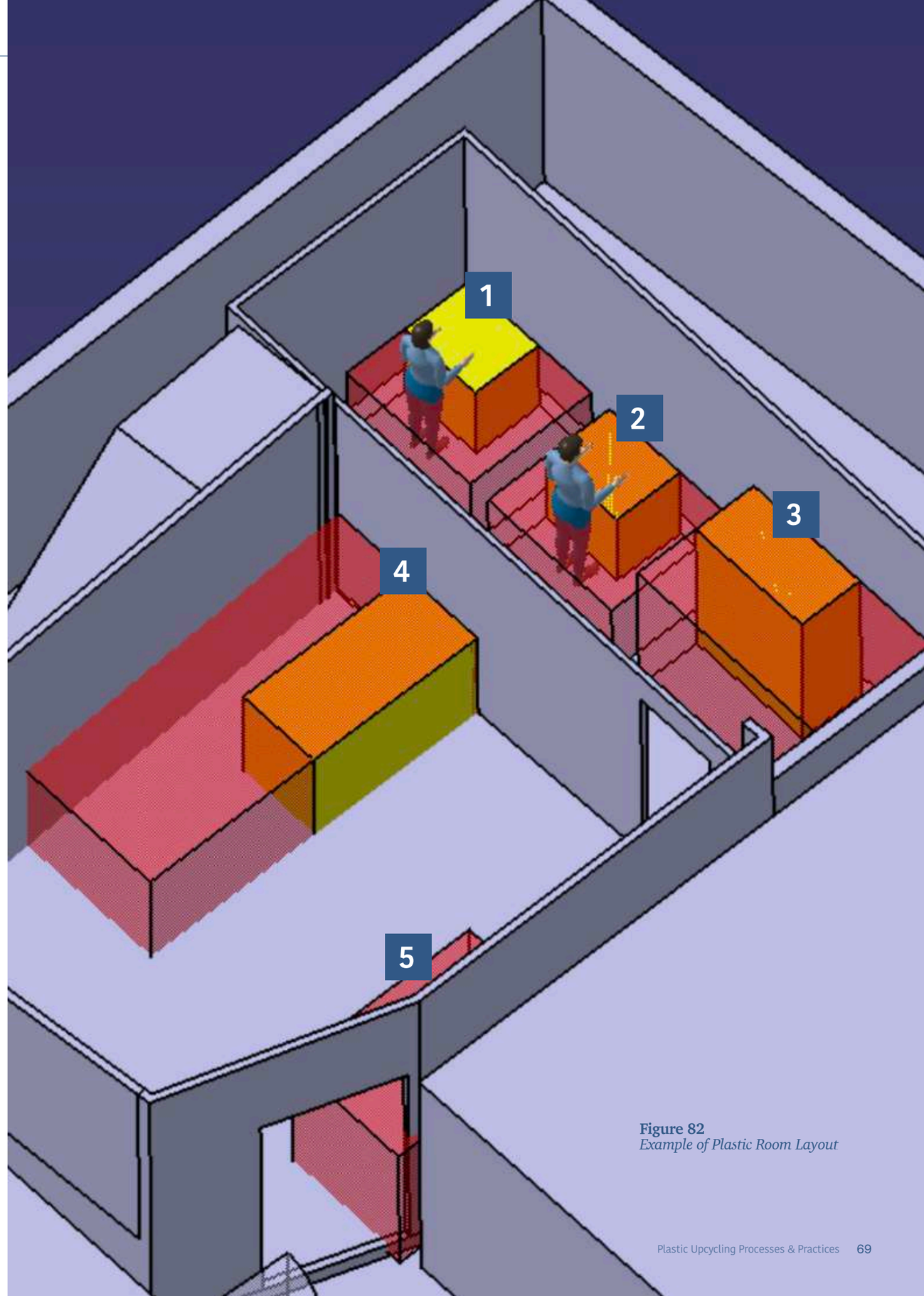

Figure 82
Example of Plastic Room Layout

5.
Product Testing

We conducted product testing with two objectives: a) to identify the optimal balance between product performance and financial viability, and b) to obtain technical evidence of our product's competitiveness compared to existing alternatives in the market.

5.1 Accelerated Weathering Test

Research Overview

Title: Exploring the Requirement for Material Property Testing for Upcycling Plastic Housing Products in Nepal
Commissioned by: Youssef Sorial, Cambridge University
Experiment conducted: 2024
Materials Tested: Three recycled plastics

- PP (recycled polypropylene)
- HDPE (recycled high-density polyethylene)
- MLP (recycled multi-layered plastic)

Purpose: Evaluate mechanical durability of locally abundant plastic waste transformed into roofing tiles for Nepal's remote Himalayan regions through accelerated weathering tests (500 hours UV exposure, moisture, and heat cycles).

Initial Mechanical Properties (Before Weathering)

- **Tensile Strength**: HDPE (20 MPa) > MLP (12 MPa) > PP (8 MPa). HDPE showed high ductility while PP exhibited brittle behavior with manufacturing defects (porosity).
- **Flexural Modulus**: PP (13 MPa) > HDPE (11 MPa) > MLP (9 MPa). PP fractured completely while others only deformed plastically.
- **Impact Strength**: HDPE (50 kJ/m²) >> MLP (15 kJ/m²) > PP (8 kJ/m²). HDPE specimens did not break; PP showed complete breaks.

Post-Weathering Results (After 500 Hours)

- **Tensile Strength Loss**: PP (-2.75 MPa) > HDPE (-2.41 MPa) >> MLP (-0.26 MPa)
- **Flexural Modulus Loss:** PP (-1.87 MPa) > MLP (-1.33 MPa) ≈ HDPE (-1.31 MPa)
- **Impact Strength**: HDPE showed dramatic decline (70% loss), changing from non-breaking to complete fracture. MLP maintained stable performance.

Comparative Analysis

- **Initial Performance**: HDPE > MLP > PP
- **After Weathering**: MLP > HDPE > PP

HDPE exhibited best initial properties but highest degradation rate, particularly in impact testing. MLP demonstrated superior retention across all tests.

Conclusion

MLP proves most promising for long-term roofing applications despite lower initial properties, demonstrating superior weathering resistance essential for durable housing products in Nepal's harsh climate.

Table 4 *Result Summary & Rate of Degradation*

Material	Tensile Loss	Degradation Rate	Key Finding
PP	2.75 MPa	34%	Poorest overall performance
HDPE	2.41 MPa	12% tensile / 70% impact	Best initial, worst aging
MLP	**0.26 MPa**	**2%**	**Most stable long-term**

For the full result:

Youssef Sorial, 2024, *Exploring the Requirement for Material Property Testing for Upcycling Plastic Housing Products in Nepal*, MPhil Dissertation, Industrial Systems, Manufacturing and Management, University of Cambridge

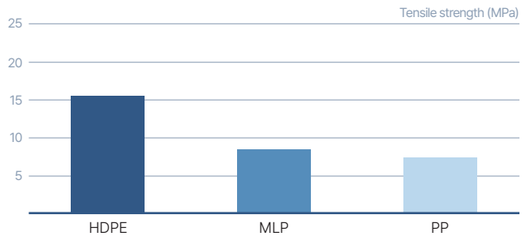

Figure 83 *Ultimate tensile strength before exposure*

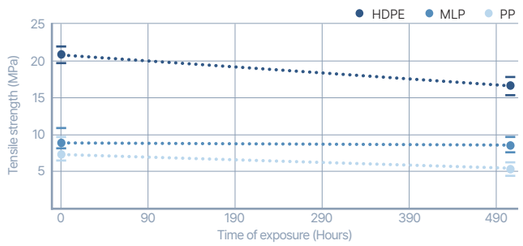

Figure 86 *Tensile strength over time of exposure*

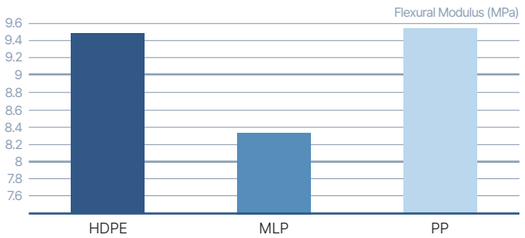

Figure 84 *Flexural modulus before exposure*

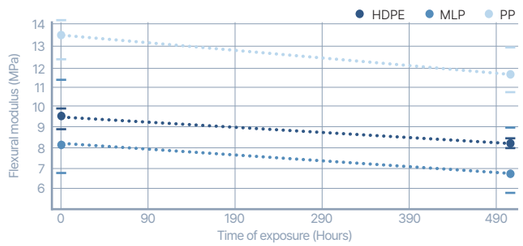

Figure 87 *Flexural modulus over time of exposure*

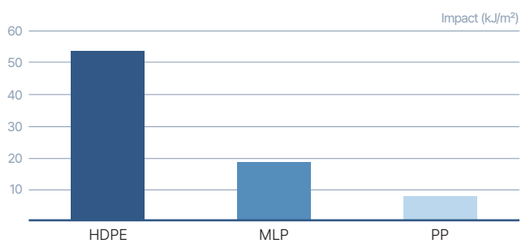

Figure 85 *Charpy impact strength before exposure*

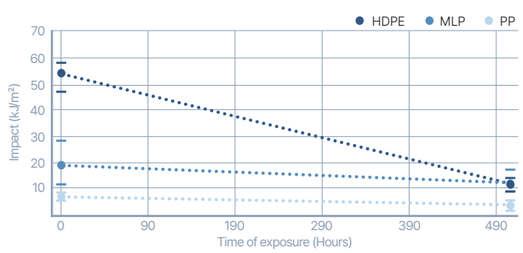

Figure 88 *Charpy impact strength over time of exposure*

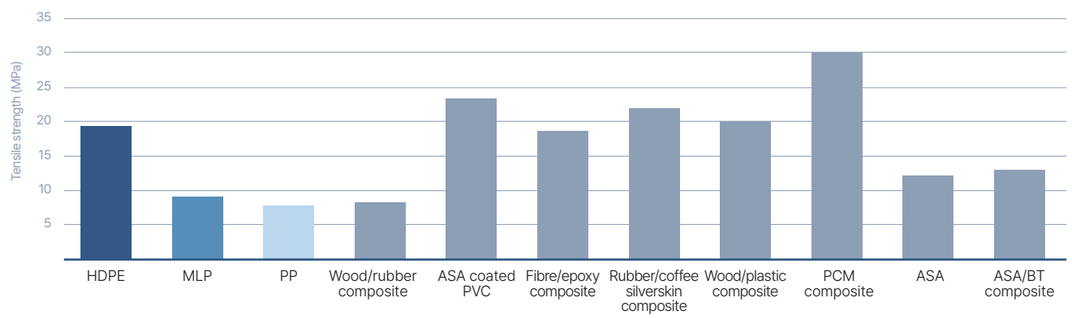

Figure 89 *Strength comparison with literature*

5.2 Product Performance Testing

Commissioned by: ESTRL lab, Kathmandu University
Experiment conducted: 2025
Nine Polyfloss insulation specimens of varying thickness (0.7–2.5 cm) and density (30–60 g or g/m³) were tested using the Steady-State Heat Flow Method to determine their thermal conductivity (k), where a lower k-value indicates better insulation performance.

Testing Method Summary

1. Specimen preparation: Ensuring uniform size and density.
2. Temperature gradient: Controlled heat applied using a hot plate and cold surface.
3. Data measurement: Heat flux (q) and temperature difference (ΔT) measured via sensors.
4. Blank correction: Accounting for baseline system heat loss.
5. Calculation: (k = qnet * d/ΔT), where d is specimen thickness.

This ensured accurate and comparable thermal conductivity values.

Observations

- Best performance: Specimen 9 (0.7 cm) and 8 (0.75 cm) achieved the lowest k-values (~0.07 W/m·K), indicating excellent insulation efficiency.
- Thicker samples (≥2 cm) generally had higher k-values (>0.28 W/m·K), performing worse due to higher density and possible internal heat conduction.
- Moderate results were seen in Specimen 6 and 7 (1 cm thick), with balanced performance.
- Specimen 6 (1 cm, denser) performed better than thicker lighter ones, suggesting that controlled density with fine pore structure can enhance insulation.

Table 5 *Result Summary Assuming Same Density*

Specimen	Thickness (cm)	Density / Mass	Avg. k (W/m·K)	Performance Note
1	2.5	60 g	0.339	Thick, higher mass
2	2.5	45 g	0.283	Thick, lighter
3	2.0	–	0.370	Poor – above typical insulation
4	1.25	–	0.289	Poor – similar to dense plastics
5	1.0	48 g	0.100	Thinner, higher mass (better than 4/5)
6	1.0	30 g/m³	0.231	Moderate
7	1.0	–	0.231	Moderate
8	**0.75**	**–**	**0.076**	**Very good (close to specimen 3)**
9	**0.7**	**–**	**0.073**	**Best performing**
Benchmark	–	–	0.022–0.045	Rock/Glass Wool, EPS, PU Foam

Key Insights and Recommendations

1) Observed Trends:

- Thinner samples (0.7–0.75 cm) with balanced density achieved optimal insulation.
- Dense, thick samples exhibited poor performance due to limited porosity.
- Moderate density, fine-fibre structure (Specimen 6) helps trap air and reduce heat flow.

2) Recommendations for Product Optimization:

- Maintain thin optimised layers rather than thick slabs to minimise conduction.
- Improve microstructure; increase porosity while avoiding large convective voids.
- Enhance fibre orientation and crimping to better trap air pockets.
- Consider surface treatments like reflective coatings to reduce radiant heat transfer.
- In application, use external or roof insulation for best thermal performance in variable climates (e.g., Kathmandu/Jumla).

Conclusion

Among the nine Polyfloss specimens, Specimens 9 and 8 demonstrated excellent insulation potential (k ≈ 0.07 W/m·K), approaching the performance of commercial materials like EPS or glass wool. Future development should focus on thin, moderately dense sheets with controlled porosity and fine fibre alignment for optimal insulation performance.

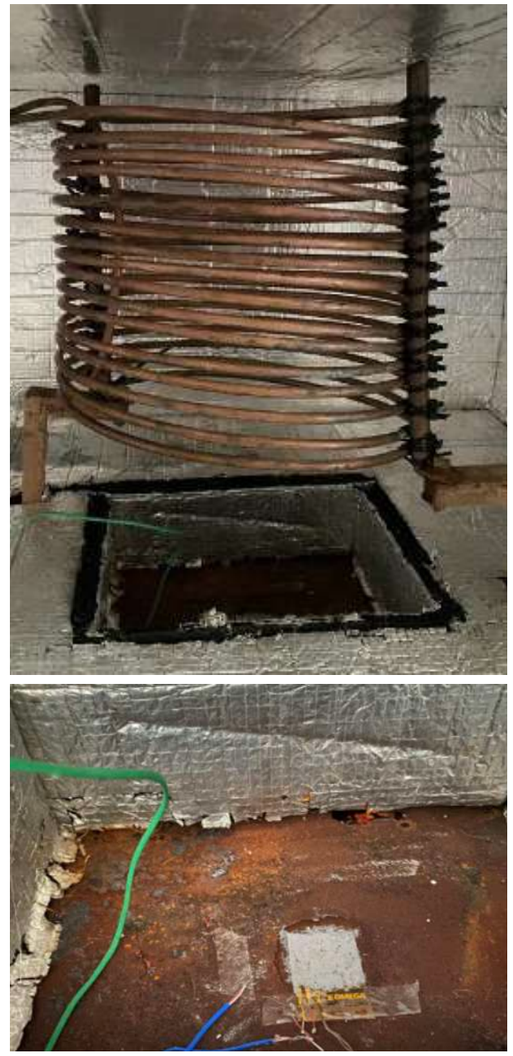

Figure 90
During the specimen testing in Test Rig

Machine Selection Decision Matrix

Template

Selection Criteria	Parameters (Weighting)	Points with weighting	
		Name of the machine:	
		Score	Score × Weighting
Mobility	**Dimension and Weight (3)** How portable is the machine?		
Affordability	**Energy Usage (2)** How much power does it consume?		
	Investment Cost (3) What is the initial purchase price?		
Appropriate Technology	**Complexity of machine (3)** How technically sophisticated is it?		
	Ease of Use (3) How user-friendly is the machine?		
Durability and Maintenance	**Robustness (3)** How durable is the build quality?		
	Repair and Maintenance (3) How easy and cheap is upkeep?		
Machine Capability	**Rate of production (2)** How fast is the output speed?		
	Precision and consistency (3) How reliable is the quality?		
	Material type compatibility (3) How many materials can it process?		
	Maximum product size (2) What is the largest item it can produce?		
Total of [Score × Weighting]			
Percentage = (Total of [Score × Weighting] / 90) × 100 **Maximum Possible Score = 90*			

Complete this template to compare machines:

1. Fill in machine names and score each parameter (1–3)
2. Multiply each score by its weighting, then sum all results
3. Calculate percentage: (Total ÷ 90) × 100, then compare to select best machine

Scoring Guide:

1 = Does not meet requirements
2 = Meets basic requirements
3 = Exceeds requirements

Example

Selection Criteria	Parameters (Weighting)	Points with weighting	
		Name of the machine:	
		T-shirt press	
		Score	Score × Weighting
Mobility	**Dimension and Weight (3)** How portable is the machine?	3	9
Affordability	**Energy Usage (2)** How much power does it consume?	3	6
	Investment Cost (3) What is the initial purchase price?	3	9
Appropriate Technology	**Complexity of machine (3)** How technically sophisticated is it?	3	9
	Ease of Use (3) How user-friendly is the machine?	3	9
Durability and Maintenance	**Robustness (3)** How durable is the build quality?	2	6
	Repair and Maintenance (3) How easy and cheap is upkeep?	2	6
Machine Capability	**Rate of production (2)** How fast is the output speed?	2	4
	Precision and consistency (3) How reliable is the quality?	2	6
	Material type compatibility (3) How many materials can it process?	1	3
	Maximum product size (2) What is the largest item it can produce?	1	2
Total of [Score × Weighting]		69	
Percentage = (Total of [Score × Weighting] / 90) × 100 **Maximum Possible Score = 90*		76.67%	

Summary

This toolkit distils the key technical learnings from building and operating distributed plastic upcycling hubs in Nepal. Complementing the P2G Safety Toolkit, it brings together our hands-on lessons, essential steps, and practical decision tools to help you choose machines, prepare materials, run equipment effectively, and assess product performance.

Use it as a practical reference as you adapt and scale your own local recycling solutions.
Together, these tools are designed to help communities build small-scale, adaptive, and locally maintainable upcycling facilities that can grow over time.

Paramendo testing floor tiles.

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