# Green FabLab Project: proposition to valorise polymer recycling in innovation spaces

Fabio Cruz[11], Hakim Boudaoud[1], Sandrine Hoppe[2], Thibaut Roux-Marchand[3], and Mauricio Camargo[1]

[1]Équipe de Recherche sur les Processus Innovatifs (ERPI), Université de Lorraine
[2]Laboratoire Réactions et Génie des Procédés (LRGP), Université de Lorraine , Nancy, France
[3]CESI , Nancy, France

[1]Electronic address: fabio-alberto.cruz-sanchez@univ-lorraine.fr

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# 1 Introduction of the Green FabLab

## 1.1 Context of the project

Since few years ago, the ERPI laboratory have been taking in place a research platform about innovation processes called the *Lorraine Fab Living Lab* (LF2L). This space joint a **«living lab»**, laboratory about the *User Centered Design* concept, with a space **«FabLab»** that allows users in an easy and quick way to fabricate intermediary objects in order to foster co-operation in engineering design [1]. Taking into account the notions of *sustainability*, which is a currently major societal issue, the *FabLab* concept goes towards a notion of ***Green FabLab*** with the purpose to better use the resources present in these spaces. This means to validate the concept of **local and distributed recycling process** thanks to the use of these innovation spaces (fablabs) and the 3D printing technology.

Figure 1.1 presents a global chain with main elements to consider in order to validate the concept. In this context, various works have been and continue to be carried out, both from a technical and logistical point of view.

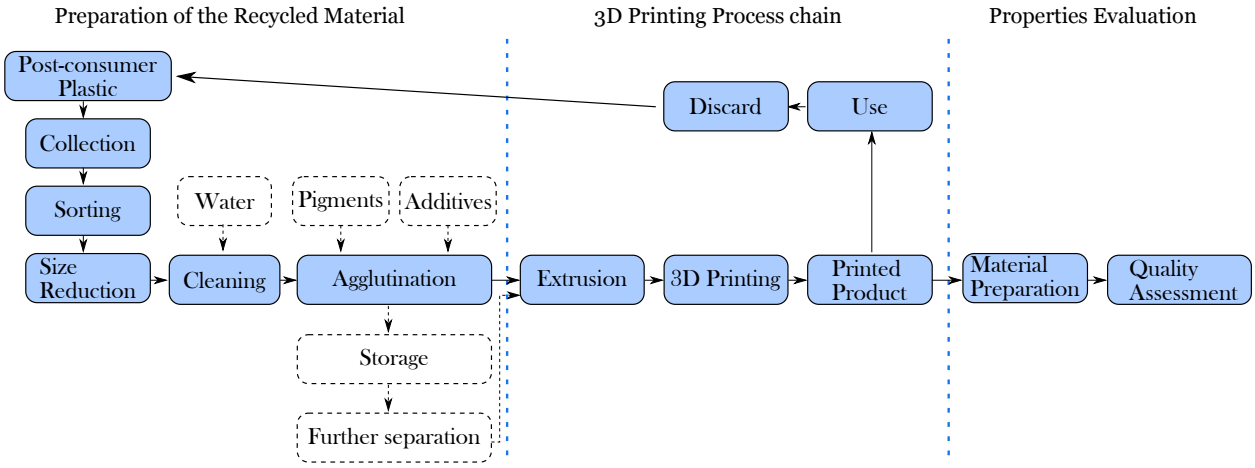



Figure 1.1: Recycling process chain for opens-source additive manufacturing

In these context, we can differentiate three main dimensions:

**Technical :** Feasibility study of the process and the characteristics of the recycled materials.

**Logistical :** Characterization of the network needed in order to obtain raw materials for local recycling.

**Usage :** Define the notion of acceptability of the use for recycled material products

In the next section we describe in detail the three main aspect to study.

## 1.2 Technical Aspect

Figure 1.2 shows the technical elements in the 3D printing chain:

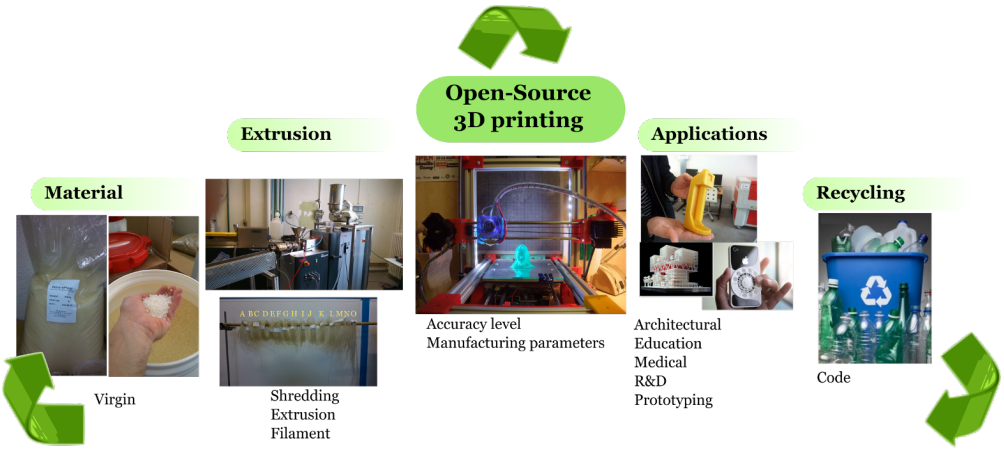
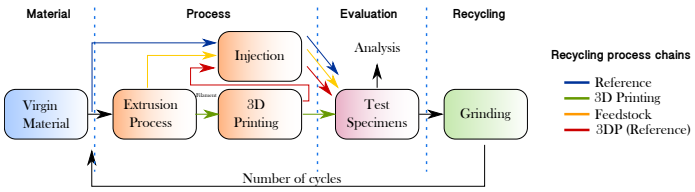
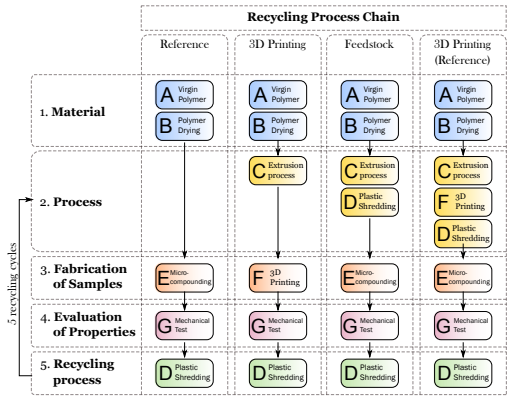



Figure 1.2: Recycling process chain for opens-source Additive Manufacturing

The research project made by Cruz Sanchez et al. [2], Cruz Sanchez et al. [3], and Cruz et al. [4], in collaboration with the LRGP laboratory, propose a methodology and a systematic process for polymer recycling with the purpose to reuse thermoplastic material into open-source 3D printers in te context of FabLabs; as illustrated in figure **??**.




(a) Methodological framework for recycling in 3DP.




(b) Operational methodology for recycling in 3DP.

The main limits of this work are:

1. Virgin material was considered as starting point of the recycling process.
2. Only polylactic acid (PLA) was tested.
3. Different processes such as *sorting, cleaning, additives, pigments* were not considered in the recycling process.
4. Laboratory conditions were used in the process. The fablab conditions are different in terms of cost, accuracy, etc.

# 2 Potential Axis of research for Green FabLab Project

## 2.1 Elements of research to explore

Table 2.1 presents some potential elements for research:

Table 2.1: Possible element to study / resolve

| **Theme** | **Focus** | **Goal** | **Based on the work of** | **Resources we need** |
|---|---|---|---|---|
| Technical | Material | Index of ***Printability*** | Antonio | |
| Technical | Material | Toxicology in 3D Printing / LCA | Antonio | LIST - Sebastian Zinck |
| Technical | Extrusion at LF2L | Calibration of the extrusion process using material of LF2L | CESI group | Repairing the Machine. |
| Logistical | Collection | Continuation of the mathematical model from Pavlo | Pavlo | Pavlo |
| Technical | Material | Test material in 3DP from LIST lab | - | Master and LIST Agreement |
| Usage | | LF2L et Fabcities : deux approches convergentes? | | ENSGSI students |

## 2.2 Some elements to explore

However, some elements to explore are:

- LF2L et Fabcities : deux approches convergentes?. ENSGSI
- **Holoprest:** a entrepreneur (Aurélien STOKY) that want to develop a manual injection machine using recycled polymer. He needs us in order to scientific base for recycling, and the use of machines. (Meeting Fabio September 12/2017). On the other hand, we can valorise the recycled material using a nw injection process in parallel with 3DP

# 3

# Research done

In order to tackle some of these limits, different works have been carry out:

## 3.1 Research made by Master MIDI students

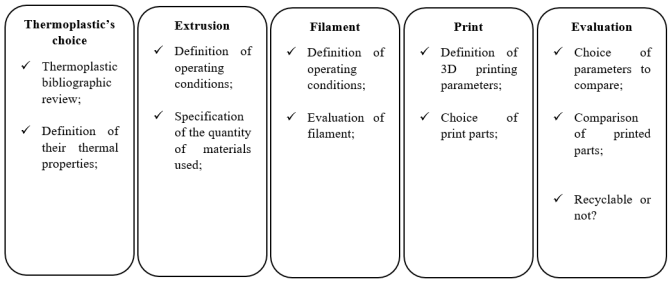
### 3.1.1 Analysis of the recycling of differents thermoplastics for 3D Printing- by Antonio Araujo

Concerning the first point of only virgin material was considered, Antonio Araujo proposed a methodology that defines in a safe way the technical feasibility of recycling a thermoplastic material for 3D printing, using the extrusion process and the additive manufacturing FDM technology.

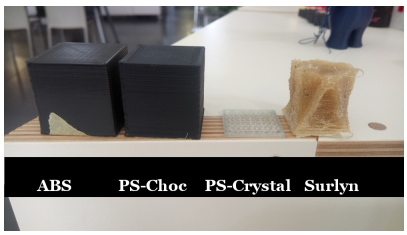
As a context for this research, four types of materials from the association Broplast were considered (figure 3.1)


Figure 3.1: Four materials from Broplast Association

Figure 3.2a shows the proposed methodology.




(a) Methodological framework for recycling in 3DP.




(b) Operational methodology for recycling in 3DP.

Figure 3.2: Methodology and results for screening aporoach for recycling process

### 3.1.2 Logistical: Model of Reverse Logistic for the compilation of plastic to recycling for the Impression 3D in the context of a Fab Lab

Concerning the logistical aspect, figure 3.3 shows the consideration for the developing of the logistical elements. The work developed by Pavlo Santander were focalised to analyze the feasibility of using a Fab Lab as a plastic recycling point for 3D impression considering its context and resources. Therefore, a logistic model to collect the plastic for the FabLab was studied. Processes such as *sorting, cleaning, additives, pigments* were not considered in the model Moreover, only schools and collegues were considered.

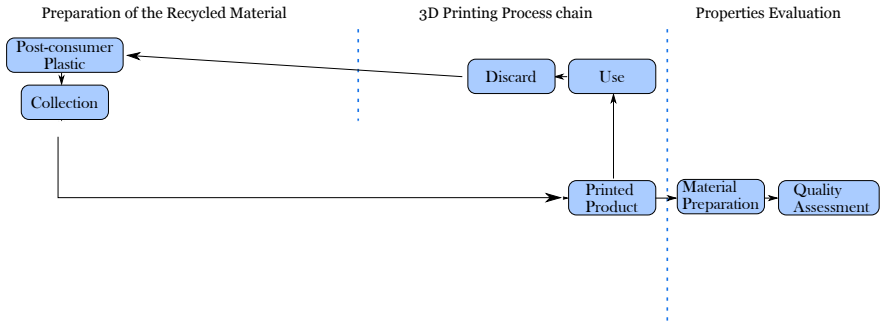



Figure 3.3: Previous results from the logistic model.

The main goals of the mathematical model were:

- Quantity of plastic to recycle
- Select best collecting points from potential sources
- Establish optimal routes
- Comparation of means of transport
- Economical and enviromental aspects

The objective function (OF) of the mathematical model is represented as a benefit to maximizing. In the context of a Fab Lab, the benefit is represented of two points of view: Operational and Environmental.

$$OF = Max[Benefice]$$
$$OF = Max[Operational\ Benefice\ (OB) + Environmental\ Benefice\ (EB)]$$
$$OB = Cost\ Virgin - Recycling\ Cost$$
$$EB = Emissions\ CO_2(Virgin) - Emissions\ CO_2(Recycling)$$

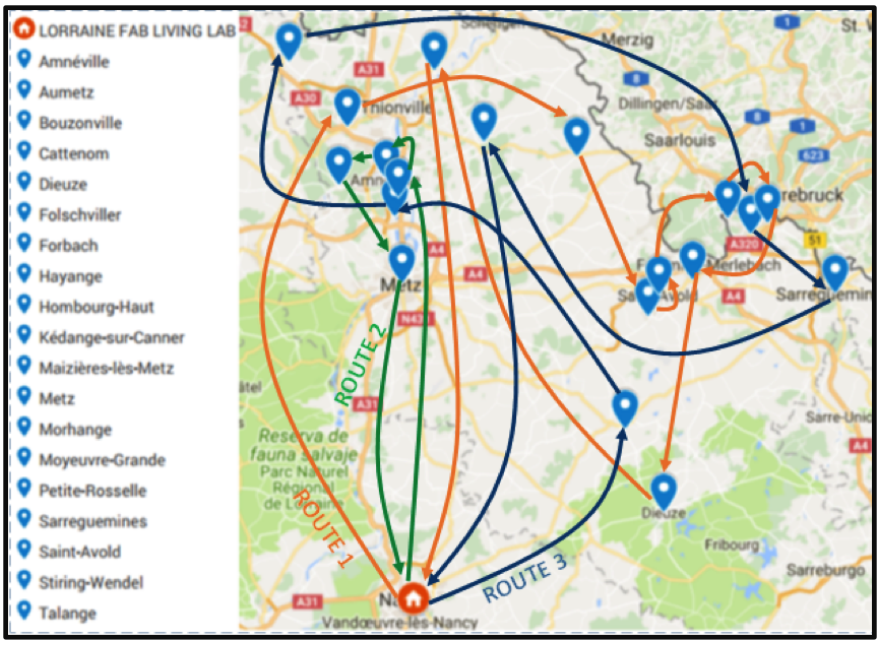



Figure 3.4: Previous results from the logistic model.

## 3.2 Research made by CESI students