ERC Starting Grant 2023
Research proposal [Part B1]

My project title

ACRO

- Principal investigator (PI): My Name
- Host institution: My University
- Full title: My project title
- Proposal short name: ACRO
- Proposal duration: 60 months

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Section a: Extended Synopsis of the scientific proposal [max. 5 pages]

DRAM in a nutshell

The aim of DRAM is to establish a blueprint methodology for the implementation of micro-chain values of distributed recycling at a urban territorial level. We seek to the achievement of a three-level target: (1) Undertand the establishment of a free-open source technical ecosystem that can be printed, 2) to establish a set indicators to possible help decision-makers and in the local implementation of these initiatives in Europe/(America?), 3) .....

1. The State of the art.

Plastics and the Antropocene: a change is needed

Plastic waste contamination is one of the relevant stratigraphic indicator of what is recently considered the Anthropocene era[1]. The anthropocene frames the humans not only as biological but as geological force acknowledging the new status of humanity given the different markups in the ecosystems that are impacting the stability of the earth system. The current globalized manufacturing activities have played a major role not only as motor for the economic development, but also the transgression of the planetary boundaries[2]. For instance, the plastic production increased at compound annual growth rate of 8.4%, passing from $2Mt$ in 1950 to $368Mt$ in 2019, but about 9% have been recycled while 79% was accumulated in landfills or the natural environment[3]. Soil and marine plastic pollution shows ecological, biogeochemical and physical thresholds and they are becoming a key component of the planetary boundary threat associated with chemical pollutants. The delay that implies to put in place an alternative productive model is the main the paradox in this issue. This implies the scientific questions on how to manage the huge amount of waste already present in the nature and the plastic waste generated in the short term expecting that materials science and industrial corpus develops feedstock in corcordance with the bio-geological cycles. Indeed, the rebound effect of the global mass production paradigm demands to rethink the paradigms of the means of production given the ecological degradation.

Getting stuck with the scale paradigm for recycling

Different routes have been developed for plastic recycling (see Figure)

From an energy and environmental perspective, the scientific literature[7] proves that the mechanical recycling strategy is the most suitable plastic waste management option for relatively clean and homogeneous plastic and bioplastic waste streams compared to landfilling or incineration alternatives.
However, transitioning to sustainable plastics in the manufacturing of plastic products, parts, and packaging is influenced by the complex interconnections between polymer producers - petrochemical companies- [10], converters [11], brand owners or manufacturers [12], retailers and consumers [13], and recycling operators [14], as well as the influences of policymakers in wider economic and societal changes [11]. Economic, social, political and technological barriers must be overcome for sustainable plastic management [9].

Major long vision: Circular and convivial production

Today, a major societal issue rely on how to conceived socio-technical 'circular units' for manufacturing that include all ecosystem externalitites considering the carrying capacity of the ecosystem. Indeed, the trend is reinforced by the fact that by 2050, it is expected that about 70% of the world's population will live in urban settlements[8]. Urban cities will be responsible for non-negligible environmental impact, producing about 50% of global waste, and 75% of greenhouse gas emissions which affects the sustainability of cities and the quality of city life[9]. The manufacturing and de-, re-cycling approaches will need to converge in a post-growth economy context need to integrate the related societal issues of resource scarcity and waste accumulation in the urban settlements[8,10].

Open source and digital commons for 'Design global / Manufacturing local'

As an alternative of globalized manufacturing values chains, a major trend in the development of production systems seeks to establish an urban production model with decentralized and distributed characteristics[11]. Aiming at a 'design global / manufacturing local' seems a proto-industrialization[12] transition that is taking place in urban settlements that could a major impact in the next short future [@]. The Open Source Appropriate Technology (OSAT) and P2P approaches have been seen potential drivers to propose an alternative globalisation manufacturing paradigm[13]. The open source additive manufacturing technology, also know as 3D printing, have played a major role in the idea of democratization of manufacturing means [@]. Thousands of open-source products are shared by the global community from consumer goods to scientific[@] and medical equipment[@]. This model has been proven to be effective for emergency manufacturing during the COVID-19 pandemic[14]. This is a driver communities to fabricate their own products for less than the price of purchasing them. In that sense, the concept of urban factory is evolving as a disruptive approach and is the materialization of this manufacturing paradigm. The urban factory is defined as "*a factory located in an urban environment that is actively utilizing the unique characteristics of its surroundings*". It creates products with a focus on the local market and allows customer involvement during value creation[11,15].

Distributed recycling for additive manufacturing: a promising inclusion

Since 2014, I have been working on the validation of the open-source 3D printing as a robust manufacturing system[16], but also as a potential enabler of the mechanical recycling[17,18] of plastic waste material. Distributed recycling (See Figure 1) is a breakthrough promise in the constitution of a micro-circular industry units to validate the technical feasibility, and several technologic pathways are maturing to allow individuals to recycle waste plastic directly by 3D-printing it into valuable products.

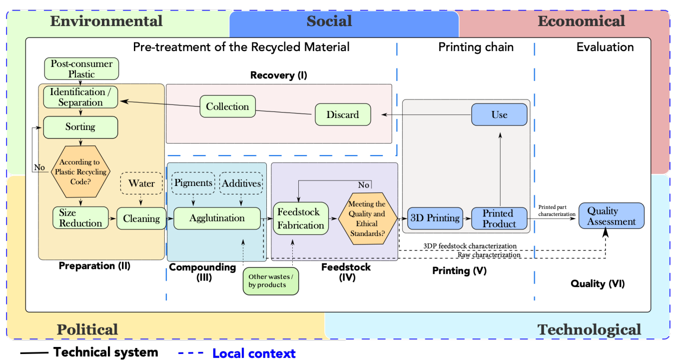

Figure 1: Distributed recycling via additive manufacturing. Source

DRAM: why now?

To appreciate the ground-breaking scientific nature of this idea, let me state that the most adopted form of additive manufacturing is fused filament fabrication, which is a material extrusion process [@]. DRAM starts with waste plastic that is produced everywhere from packaging to broken products. It is washed, dried and then ground or cut into particles using a waste plastic granulator or office shredder. Next, the particles are either converted to 3D-printing filament using a recyclebot or printed directly. Filament made with a recyclebot costs less than 10 cents per kg, whereas commercial filament costs $20/kg or more. This can produce valuable products at remarkably low costs. For example, using a recyclebot/3D-printer combination can produce over 300 units (e.g., camera lens hoods) for the price of one such item listed on Amazon.com. The raw material for FFF can be manufactured economically using distributed means with a waste plastic extruder (often called a "recyclebot")[19]. Recycling of plastic waste into 3-D printing filament decreases the embodied energy of filament by 90% compared to traditional centralized filament manufacturing using fossil fuels as inputs[20,21]. Distributed recycling fits into the circular economy paradigm[22–24], as it eliminates most embodied energy and pollution from transportation between processing steps. Additionaly, open-source investment should result in an extremely high return on investment (ROI) in free and open source hardware[ref?]. This makes distributed recycling and additive manufacturing (DRAM) environmentally superior to other methods of plastic recycling.

However, using a systematic literature review, I realized that the system maturity the technical value chain for the implementation of a community-driven of plastic recycling is ambiguous[25]. Major efforts in the scientific literature have been only concentrated in the materials and technical validation.
However, the system validation remains to be difficult to implement. More in deep, the analysis of the

holistic impact that this process can have in the context of a city remain vague, if not, not treated at all. In particular, this will is important if a recycled resources industry (RRI) is starting to conceived inside the cities. RRI is seen as driver consists of a series of activities related to recycled resources – e.g., recycling, refining, remanufacturing, etc. – aspiring to mitigate the negative externality caused by the linear economy[26]. The sustainable development of the RRI has thus been highlighted on many countries' agendas to promote the circular society[27–29], as well as the goals of carbon peak and carbon neutralization. The main difficulty remains to make affordable the use of new secondary material applicability by the industry[30], but at the end, for urban planning and polycimaking to make concrete the ambition of circuclar economy inside the urban and regional settlements.

2. Ambition, objectives

Plastic recycling remains at systemic problem, and *there is a urgent necessity to better understand the major barriers and drivers to design and deploy sustainable and inclusive micro-recycling values chains inspired on the "Design Global / Manufacturing local" principles.* How to develop an industrial ecology network for recycling, given the uncertainty of the thresholds of sustainability, ecological and social for these type of projects ?

How to deal with the technological choices for establisment 'local circular units'? These question are not yet well answered.

SDRAM's goals: a systemic blueprint to understand the distributed recycling approach

The purpose of SDRAM project is create a systemic blueprint to better understand the design of socio-technical distributed distributed recycling approach in urban settlements.

As a systemic blueprint, i mean to consider the technical, sytem and valuation layers (See Figure XX) The major gap that currently prevents from exploring the potential of distributed recycling relies on a missing a holistic understanding of the design for sustainability[31,32] of socio-technical system in a context of 'Spaceship Earth', as an apt metaphor to chart the boundaries for a safe planet[**sterner2019?**]. This implies going from the technical (molecule , process unit) to the ecosystem impact of the implementation.

A challenging task

From a major scientific, DRAM seeks the achievement of a three-level target (See Figure XXX). : 1) The design of an open source appropriate technical ecosystem (OSAT). 2) Develop proposiong a systems dynamics methodlogy 3) Develop new forms of valuation of these micro-values chains that integrate ecosystem characteristics.

- *the development of appropriate technologies is fundamental.* Technological choices and applications that are small-scale, economically affordable, decentralised, energy-efficient, environmentally sound and easily utilized by local communities to meet their needs are needed [@] Therefore, the trend in appropriate technologies is towards relatively simple and non-complex technologies, to complete the technological mix to be capable of plastic recycling from the identification of material, cleaning, sorting. The development of open hardware scietnific are considered as an excellent choice to reduce the cost [@]. The creation of a technical blueprint is there is no a database that include is regarded as the front of
- *Systemic design thinking is needed to identify major feedbacks in the strategic, the tactical and the operational decisional levels.* Reconciling urban development and industrial development is not an easy task. Particularly, in the use of plastic materials. Thus, the type of information that decision-makers take into account is relevant at the moment to put in place industrial systems.
- Create a new forms valuation Fro the ecological economics science, it is stated to analys socio-technical sytems beyond the economics [@], to include new form of pluralims valuation to include the ecological interactions[@].

In order to allow exploration of a new science domain, based on the multi-echelle and multi-acteur.

3. The Methodology

SDRAM implemnest a methodology made of four working packages (WP), as illustrated in Fig.

The firs phase correspond

Axe 1: development of a open-source technodiverstity for recycling

Axe 1: Systemic analysisi in function of the local territory

- Development of methodlogy to identify potential urban disposal sites connecting

Axe 3: Circular bussines model for recycled communities

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Axe 4: Propospective recomendation through delphi analyss?

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An Impact project

Resources and budget

The research team

The budget requied for the development of SDRAM is XXX €. The most significant cost is the personnel cost (XXXX € - XX %). Minor cost cover the purchase of experimentl open hardware equipement (XXXX € - XX %), travels for dissemination of results (XXXX € - XX %), Open acces fees for at least 8 publications (XXXX € - XX %).

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