Section a: State of the art and objectives

DRAM in a nutshell

The main purpose of the Systemic Distributed Recycling via Open Hardware (SDROM) is to establish a blueprint methodology for the design, implementation and (e)valuation of micro-value chains of distributed recycling at a urban territorial level. We seek to the achievement of a three-level target: 1) Understand 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) .....

Section a. State-of-the-art and objectives

Plastics and the Antropocene: a change is needed

In the current paradigm, mass manufacturing plastic products are often globalized value creation chains. The mass production system, in the lens of a deep transition[1] framework, is the fruit of a complex co-evolution of single unit productions and interconnected systems that have intensified several forms of environmental degradation without fully assuring the social foundation's minimum standards (e.g. healthcare, energy, water etc)[2]. Thus, humanity is not only a biological but a geological force, and this is what is recently considered the Anthropocene era.[3,4]. This new status of humanity is given the different indicators in the natural ecosystems that are impacting the stability of the earth system. For instance, the plastic waste contamination is one of the relevant stratigraphic indicator[5,6] . More precisely, the soil and marine plastic pollution shows ecological, biogeochemical and physical thresholds and they are becoming a key component of the planetary boundaries[2,7,8] threat associated with chemical pollutants. Then, the use and disposal of plastics is a societal problem characterized by high complexity and multifaceted feedback loops that calls for a systemic view of the entire plastics value chain from producers -petrochemical companies-[9,10], converters[11], brand owners or manufacturers[12,13], retailers and consumers[14–16], and recycling operators[17,18], as well as the influences of policy-makers in wider economic and societal changes[11]. The delay that implies to put in place an alternative productive model is the main the paradox in this societal issue. Therefore, how to manage the huge amount of waste already present in the nature and the plastic waste generated in the short term?, How to rethink production, consumption systems (and even urban future cities) based on an engineering that is concordance with the bio-geological cycles?, What are alternative trajectories for a socio-technical productive systems that take into account the natural capital and externalities[19] since the fuzzy front-end design phase?. These major scientific questions remains open towards a sustainable transition of socio-technical model.

Towards circular cities: a promise to fullfill

Various schools of thought are proposing alternative socio-technical manufacturing systems (and in some cases consumption), based on circular economy[20], bioeconomy, frugal innovation and degrowth. The circular economy concept in the policy[21], industrial[22] and scientific[23–25] arenas as an umbrella concept, but also as a contested one[26–28]. CE has been conceptualized as an ecological modernization project that builds on capitalist economic growth narratives. On the other hand, degrowth proponents argue that economic growth cannot be sufficiently decoupled from environmental impacts, which renders further growth of the economy unsustainable. IN any case, many cities have taken up the resource management discourse to design circular economy action plans, which aim to reduce urban environmental impacts while generating new jobs, social well-being and room for innovation. Working to make cities more circular implies adopting a

particular approach, using the concept of "territorial metabolism," designating "the set of energy and material flows brought into play by the functioning of a given territory"**refBarles?**.
This approach consists of understanding cities as the result of a specific socio-ecological regime, no longer solely through their functions or activities, but through their flows and stocks of materials and resources. Indeed, cities worldwide are committed to becoming more circular in their resource use. Looping actions —reuse, recycling and recovery of resources (materials, energy, water, land and infrastructure)— can help to address resource scarcity and wastage in cities. However, whether or not their actions help them to reduce their environmental impacts is unclear[29,30] and there are many challenges to implementation (Institutional, Political, Regulatorial, Socio Economical)[31]. Particularly, the key challengue lies in the bridging the boundaries of urban planning and urban production systems a one coherent, continuum and multi-scale design process[32–34].

Openess for 'Design global / Manufacturing local'

A major trend in the development of production systems seeks to establish an urban production model[32,34] with decentralized and distributed characteristics[35,36] as an alternative of globalized manufacturing values chains. Aiming at a *'design global / manufacturing local'* (DGML)[37] seems a proto-industrialization[38] transition that is taking place in urban settlements that could a major impact in the next short future. DGML is an emerging productive model that builds on the convergence of the digital commons of knowledge, software and design with local manufacturing technologies. More precisely, the Open Source Appropriate Technology (OSAT)[39] and peer-to-peer (P2P)[40] approaches have been seen potential drivers to propose an alternative globalisation manufacturing paradigm[41].

The open source (OS) approach has become well-established to provide improved product innovation over proprietary product development[42–45]. The evidence is most mature for software development because free and open source software (FOSS) provides: i) diversification and open innovation[46–48], ii) cumulative innovation[49], iii) development efficiency[50], iv) organizational innovation[48], v) higher technical quality of code[51], vi) encourages creativity[52] and vii) perhaps most importantly, it avoids redundant work[53]. The OS approach is now also gaining traction in free and open source hardware (FOSH)[54–58] and appears to be roughly 15 years behind FOSS in development and adoption[59]. One of the primary drivers, is that all forms of free and open source technology software and hardware (FOSS and FOSH) can provide a substantial cost savings[60–63].

The open source additive manufacturing technology, also know as 3D printing, is playing a major role in the idea of democratization of manufacturing means[64,65]. In particular, material extrusion based units are widely used, thanks to the simplicity of operation, the Do-It-Yourself (DIY) approach and the open-support communities. Thousands of open-source products are shared by the global community from consumer goods to scientific[66] and medical equipment[66,67]. This model has been proven to be effective for emergency manufacturing during the COVID-19 pandemic[66,68]. 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[32,69].

Major long vision: Convivial urban production

Today, a major societal issue rely on how to conceived socio-technical 'circular units' for manufacturing that integrates values of sobriety**ref?**, resilience[70,71], adaptability[72] and evolutive in urban settlements. The technologies that tend to lean towards sufficiency and creativity; adopt the open-source philosophy; are designed for affordability and durability; explore tacit knowledge; empower communities through access to means of production; and promote localisation of production and logistics; are defined as **convivial**[35]. Moreover, the reuse, repairing, recycling approaches will need to converge in a post-growth economy context considering the societal issues of resource scarcity and waste accumulation in the urban settlements[73,74]. Indeed, today the establishment of these socio-technical systems need to include all ecosystem externalitites and the carrying capacity of the ecosystem to claim to sustainability[75,76]. 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[74]. Urban cities will be responsible for non-negligible environmental impact[77,78], producing about 50% of global waste, and 75% of greenhouse gas emissions which affects the sustainability of cities[79] and the quality of city life[80].

Distributed recycling via additive manufacturing: a promising inclusion

Since 2014, I have been working on the validation of the open-source 3D printing, filament-[81] and pellet-based[82], as a robust manufacturing system, but also as a potential enabler of the mechanical recycling[83–85] of thermoplastic waste feedstock. Likewise, I have been working on the design of the pertinent closed-loop supply chain[86,87], considering the social political, technological and technological indicators[88] based on the scientific literature. In a recent paper[89], I could establish the *distributed recycling via additive manufacturing (DRAM)* as a conceptual model to possible establish the complete recycling process. DRAM (See Figure 1) is a breakthrough promise in the constitution of a micro-circular industry units to validate the technical feasibility, and several technological pathways are maturing to allow individuals to recycle waste plastic directly by 3D-printing it into valuable products.

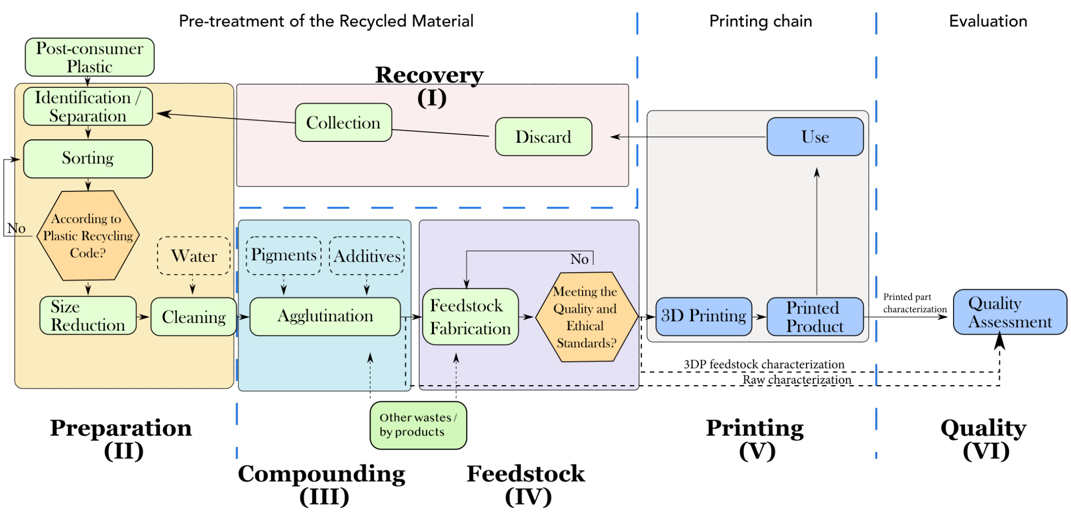

Figure 1: Distributed recycling via additive manufacturing. Source

To appreciate the ground-breaking scientific nature of this idea, let me state that historically, the plastic recycling has been oriented to centralized facilities in order to take advantage of economies of scale through the production of low-value products. However, it is proved to be an expensive process due to the inherent separate collection, transportation, processing and remanufacturing[90,91]. Plastic production increased at compound annual growth rate of 8.4%, passing from $2Mt$ in 1950 to $368Mt$ in 2019, but the statistics proves that only 9% have been recycled while 79% was accumulated in landfills or the natural environment[92]. **We need other paradigm to tackle this wicked problem**.

On the other hand, DRAM can starts with local plastic waste that is produced everywhere from packaging to broken products (*Recovery (I)*). It is washed, dried and then ground or cut into particles using a waste plastic granulator or office shredder (*Preparation (II)*). The raw material for filament feedstock can be manufactured economically using distributed means such as waste plastic extruder (often called a "recyclebot")[93] for mono-materials (*Compounding (II) and Feedstock (IV)*). 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 marketplaces (e.g. Amazon). Fused granular fabrication is a recent experimental approach enabling the printing process directly from pellets[94,95], which reduces the degradation cycles of the plastic. For this process, I worked in the desktop format[82], but it seems that this technology could further expand the boundaries of additive manufacturing and eventually recycling[96–98] for larger objects (60X60cm) using opeen hardware[99]. Distributed recycling fits into the circular economy paradigm[100–102], as it eliminates most embodied energy and pollution from transportation between processing steps. Also, it decreases the embodied energy of filament by 90% compared to traditional centralized filament manufacturing using fossil fuels as inputs[103–105]. Additionally, open-source investment should result in an extremely high return on investment (ROI)[66]. This makes distributed recycling environmentally superior to other methods of plastic recycling systems.

The scientific problem: Connect the dots of City-Product-Recycling nexus.

Major efforts in the DRAM scientific literature have been only concentrated in the materials and technical validation in laboratory conditions. However, *the holistic impact that distributed recycling can have in the context of an urban city suffers from the critical uncertainty of its relevance in implementation and (e)valuation affecting the support and monitoring of this urban strategy.* From the urban planning perspective, there are not methodological tools to (e)valuate (to see the impact but also to see the worth) of possible distributed plastic networks supported by the open source. Indeed, a community-driven of plastic recycling remains in the makers, Fablabs spheres where the competences and values may from the general public. A system validation is needed to possible understand the pertinent scale that his approach can take in urban settlements and to show the limits that can entail (Jevons Paradox[106], Waste-Resource Paradox[107]).

First insigths towards a systemic analysis.

In the framework of a EUH2020 project called INEDIT[1], I have been leading the implementation of the **Green Fablab** demostrator inside the third place called Octroi-Nancy Association [2] since November 2021[3]. INEDIT project aims to create an ecosystem to transform the DYI practices largely documented in FabLabs/Hacker/Maker spaces into a professional approach called Do-It-Together to capitalise on the knowledge, creativity and ideas of design and engineering. The Green Fablab is a distributed recycling demonstrator that use living lab approach[108,109] to experiment in real conditions with citizens, final users and large general public. This experiment is enframed as a design for sustainability at a socio-technical system level[110]. We have collected and recycling around 100kg of plastic waste for the pedagogical and architectural uses given the fact that we are connected with a creative ecosystem of designers and makers participatin in the Octroi-Nancy projet. This hands-on experience confirms the literature that a new recycled resources industry is starting to conceived inside the cities[111]. This industry 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. More deep insigths seeks to promote towards a circular society[112–114]. In the case of plastic waste, the main difficulty remains to make affordable the use of new secondary material applicability by the industry[115], but more profoundly, how these new socio-technical technical systems will interact with the urban planning

[1]See https://cordis.europa.eu/project/id/869952
[2]See https://www.octroi-nancy.fr/
[3]This demostrator found retard because of the pandemic situation.

process and policymaking to make concrete the ambition of circularity inside the urban settlements.

2. Ambition & objectives

The material' rarefaction[116], the need for ecological integration of manufacturing systems[76,117,118] and the urban resilience[119] calls for pushing forward the boundaries of knowledge of the design of urban production systems to unleash a sustainability transition.

Therefore, the main objective of this project is **to establish a systemic methodological blueprint to fully understand how to design, implement and (e)valuate urban distributed recycling systems based on the Open Source Appropriate technologies**. The deployment of circularity marks a return to a more productive design of the city, that must consider the natural and urban ecosystem services, the strengthened of the resilience capacities and taking into account the energy sobriety of european territories. Thus, this project seeks two level targets:

1) The scientific understanding of the design of socio-technical configurations of urban production systems based on distributed plastic recycling as resilience strategy.

2) Holistic and pluralistic (e)valuation of the open source appropriate technologies and design as assets for urban territorial development.

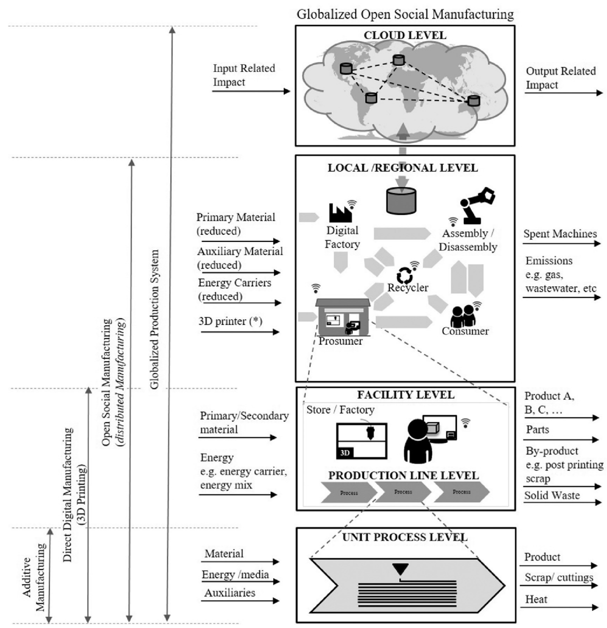

Figure 2: Methodology

I aims further develop the distributed recycling three major layers and the boudaries objects to connect them the as illustrated in figure 2 (1) technical layer (2) urban layer (3) Evaluation layer.

Based on that, table XX presents an outline of the research question of the three major layers to consider in this project.

Challenge 1: Urban systems' role in the deployment of the circularity.

In order to identify the design process of an urban circular production system, some relevant questions are the following:

- How to dimension production systems to be consistent with the resources and materials (recycled plastics) (first and second hand) considered as local ?
- How to establish the link to integrate territorial planning priorities with respect to production systems priorities within an urban circular economy context?
- What are the acceptability conditions for the deployment of urban demostrators of circularity?
- How to identify the opportunities and barriers from a social, technological, political and legal point of view for the implementation of an urban production/recycling network?
- What strategies can be implemented so that socio-technical systems of circular production can be in line with urban needs and their contribution to the SDGs?
- How to establish an open source value chain in order to foster resilience and technological and energetic sobriety of the urban territory?
- In what extend the implementation of urban production systems affect the functional blocks of an urban territory?

Challenge 2: Systematize the open source technodiversity as territorial asset.

To implement an open source appropriate technology ecosystem suitable for circular urban production system, some relevant research questions are the following:

- How to design a technodiversity baseline based on open source appropriate technologies (OSAT) for distributed recycling?
- How can the design process of an appropriate open source technology be analyzed to avoid what is known as the Jevons paradox?
- How to facilitate the adoption of open source practices and tools, for a public that goes beyond the fablab/makerspaces that have been pioneers?
- What would be the relevant business model for open hardware adoption to allow the introduction of open source tools and practices?
- How to evaluate the degree of maturity of a small company so that within its strategy it can implement the adoption of open hardware as a disruptive practice?
- What open source technologies needed to develop and implement a urban closed-loop suply chain ?
- How open source technologies would allow the development of urban productive systems in coherence to favor the resilience of the territory?
- What are the core competences needed in an open source ecosystem for urban circularity?

Challenge 3: Pluralistic (e)valuation of distributed recycling units and networks.

In order to (e)valuate in a pluralistic way the development and implementation of urban distributed units, some relevant questions are the following:

- How to connect ecological and economic indicators within the same evaluation framework?
- Which territorial and production system indicators would make it possible to establish a minimum scale of operation, but also a maximum scale that respects urban ecosystem services?
- How to establish scenarios of evolution and impact so that territorial decision-makers can encourage the adoption and piloting of these initiatives?
- What would be the relevant functional unit to delimit the range of action of the production/recycling system within the urban metabolism?
- What are the necessary considerations to represent the preferences of the stakeholders in the decision-making process of integration urban / manufacturing systems?
- How to support the process form collective consensus to the deployment of these emerging systems under a purpose oriented approach?

3. An Impact project

- **Main scientific impacts.**

  1) This project aims to make a breakthrough ontological contributions on the understanding of the implementation and evaluation of **distributed recycling** as a socio-technical unit for urban sustainability transition.
  2) In the sustainable transitions research, This dilemma has evoked significant efforts to move beyond the single-case embracing of irreducible complexity, involving modelling approaches and indicator development. This remains one of the main methodological frontiers for transitions research.

- **Main societal impacts.** If the expected results are confirmed, the outcome of this project will allow urban and technical desicion-makers the implementation of local distributed recycling circuits. In the case of this project, the focus is plastic waste. However, we expect that the systemic blueprint can be applicable to other value chains that available plastic waste by means of small, distrubuted recycling socio-technical units for plastic recycling.

Section b. Methodology

3. Introduction the scientific methodology

This project implements a methodology made of four working packages (WP), as illustrated in Fig. 3. We recognize pertinent intermediate objectives (tasks) and we individuate the specific interventions of the members of the research team. Moreover, we discuss the particular methodologies that we plan to adopt and we make a balance among the risks and gains associated to each action. The aim of WP1 is to set a baseline for an integrative and generic analysis of urban territory in the frame of micro-value chains for manufacturing/recycling production. This working package gives the insights for the WP2, and WP3, which are key of the project. The WP2 seeks to consolidate systematize a design process for OSAT for a complete distributed manufacturing/recycling process establishing an unit maturity level index, but more important, a system maturity level for

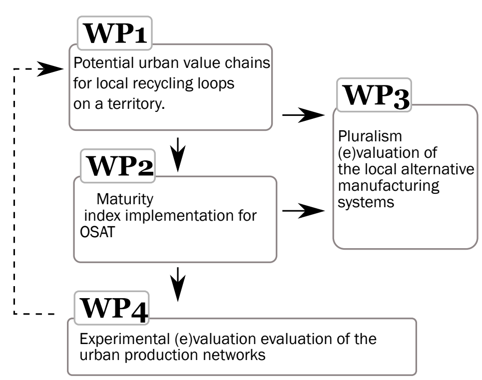

Figure 3: Methodology

the integration into an urban ecosystem. The main output is to establish a complete OSAT design framework ecosystems to valorize the waste niches opportunities identified in WP1. The WP3 aims to identify a pluralistic (e)valuation framework for the urban closed-loop system network integrating three essential issues: sustainability, resilience, and agility into a circular economy praxis. Finally, WP4 is dedicated to the experimentation of the several case studies of the urban circular manufacturing taking as exemple into at case studies the implementation of the Green Fablab Project at the third place of OK3 at Nancy-France. The object is to replicate this analysis at least in three european territories. Work packages are synthetically detailed hereinafter.

WP 1: Theoretical baseline analysis for closed-loop urban value chains

Main objective: This WP deals with the theoretical grid analysis to unfold the potentials micro-value chains and exchange flows induced by distributed recycling at urban territories. This framework is based on the urban spatial analysis and stakeholders characteristics as an entry point for the distributed. The distributed recycling considering the different characteristics of urban municipalities. In this work package, the major output will be an methodological tool to possible be the input for WP2 and WP3.

Task 1.1: Closing the data gap: Main objective: The goal of this task is to define a *{territory x material}* index from an urban metabolism to study resource use in a urban city. This assessment aims to quantify hotspots (availability vs complexity) based on territorial and footprint indicators and assess scenarios for the design of a recycling closed-loop supply chain.

- **Step 1**: Proposition of a generic territorial diagnostic approach to fully identify relevant recycling actors in the centralized urban waste management systems.
- **Step 2**: Based on a systematic/integrative literature review, establish data baseline on the major barriers stakeholder in the centralized urban waste management systems. and confront the literature with a qualitative methods (e.g. semi-structured interviews) to validate the identified barriers in the recycling system.
- **Step 3**: to establish a methodological framework that close the existing data gaps in terms of secondary plastic material availability at the urban level considering its omplexity level of revalorization. The monitoring and assessing material consumption and material productivity is critical, both from a macroeconomic perspective — to assess whether sufficient action has been taken, as well as from a local perspective— to support local decision makers in setting new priorities toward long-term objectives[120]. For the case of plastic material, this is particularly relevant given ambitious circularity targets that certain governments have putting in place due to the their impact.
- **Step 4**: To reveal a list of 'suitable' secondary materials wastes at the urban level that today are not fully understood and valorized. This analysis will be carried out at least in three urban municipalities in Europe at least every year, and if possible more frequently to see if there is a change or seasonality in the composition of this untreated waste.

Task 1.2: Identification of the the urban territorial priorities in the frame of ecosystems services. Main objective: The main aim in this task is to identify the urban priorities based on the ecosystem services (ES) framework. A methodological analysis will be started in this task in order to confront the urban development priorities with urban industrial priorities.

- **Step 1**: Literature review and critical analysis of the Urban Ecosystem framework.
- **Step 2**: Establish a questionnaire / data collection to apply a participatory approach on the identification and priorization by local territorial actors.
- **Step 3**: Establish a valuation approach to quantify the potential supply of ES that urban territory can give for a potential distributed recycling system. This project aims is to quantify and valuate the potential supply of ES that urban territory can give for the potential distributed

recycling system.
- **Step 4**: To estimate the damage that plastic waste not valorized have on the the urban territory in terms of ES.

The use of ES as boundary object for sustainability for diverse stakeholders[121], entails the necessity to create knowledge for transdisciplinary approaches.

Delivrables

- D1 [M9]: A generic territorial diagnostic to possible potential plastic waste at the urban level.
- D2 [M18]: Identification of the transversal and particular barriers in the centralized systems at the urban level.
- D3 [M27]: Implementation and evaluation of the *{territory x material}* index as possible to estimate the potential stock of plastic waste to valorize.

WP 2: Maturity and technodiverstity level of the OSATs for distributed recycling.

Main objective: In parallel of WP1, the WP2 will be focused on the unit- and system-level to propose the design process for open source appropriate technology can be implemented in urban distributed recycling networks. The purpose of this task is to analyze the technodiversity of the complete technical chain for distributed recycling. This analysis aims to leverage the baseline for a resilient manufacturing[119,122].

Task 2.1 Modularity, Openess and Conviviality index of a complet OSAT technical chain. The purpose of this task is to possible identify an theoretical index that can illustrate the robustness ans adaptability of the open hadware for distributed recycling.

- **Step 1**: to establish a complete database of the existent OSATs associated to each majors phases of distributed recycling (I - IV in figure Figure 1) identifying also the gaps in to be filled in hardware development. These initial mapping will be based on on open source hardware from scientific literature (e.g. HardwareX journal) and from grey/maker literature repositories (e.g. Github, Forums, Precious Plastic).
- **Step 2**: a quantitative analysis based on the network science will be made to evaluate the modularity type[123] of the avaialble OSATs found in step 1.
- **Step 3**: a qualitative analysis on the openess[124] and the conviviality matrix[125] will also be performed to the OSATs of step 1.
- **Step 4**: Consolidate to consolidate a multi-criteria database of the technodiversity development of distributed recycling identifying the gaps in terms of open hardware developmment.

Task 2.2 Mapping of new/adapted practices and tools for OSAT adoption: The main of this task is to identify the adoption hinders and the technological lock-ins of open hardware for distributed recycling. Recently, using interpretative structural modeling (ISM) methodology, 22 technical barriers were identifying in the adoption from the maker perspective[126].

- **Step 1**: we will make a deeper analysis in how mayor factors like stability and modularity and active ecosystem can possible give answer to these technical challenges based on recent experiments of open hardware ecosystems[127,128].
- **Step 2**: A definition of key performance indicators from a scientific will highlight the priority to support *practitioners* overcome the challenges of distributed recycling for the adoption of industrial actors (e.g. SMEs).

Task 2.3 Identify the techno-ecological synergy for an urban closed-loop supply chain. The aim of this task is to establish a techno-ecological synergy[129,130] combining the Ecosystem services and the Life cycle assessment[131–134] for the case of distributed recycling.

- **Step 1**: the ES identified in the task 1.3 from the perspective of the urban territory will be confronted to the ES that the industrial configuration will need and eventually provide.
- **Step 2**: To define a initial connection of the urban and technical layers using the techno-ecological framework and the LCA.
- **Step 3**: Definition of unified model that can be use in the evaluation phase considerint the main indicators, criteria and principles.
- **Step 4**: Establish a Multi-Criteria Decision Making (MCDM) approach for selecting the best technical configuration of the closed-loop supply chain in fuction the steps 1-3 and the territorial analysis.

WP 3: Pluralistic evaluation of distributed recycling systems

Main objective: The WP3 aims to assess the urban and technical layers to better understand under which conditions the distributed recycling urban chains are pertinent for a urban territory.

Task 3.1 Structuring a systems dynamic causal loop model: The main aim in this task is to reveal the components and the structure of the urban circular networks to the combining Material Flow Analysis[135], System Dynamics[136–140] and Circularity Indicators[141]. One strategical point in sustainability relies on the integration of the outputs of Task 2.3 explicitly in the modelling

- **Step 1**: Definition of the major components of the systems, with initial parameters
- **Step 2**: Establishment of the qualitative causal loops
- **Step 2**: Quantification and mathemathical modelling of the established causal loops.

Task 3.2 Definition of the plausible hypothesis and evolution scenarios: In this task, the main idea is to possible establish plausible prospectives scenarios of evolution considering the scale of action considering the technical maturity, economic viability and environmental respect of the ecosystem services.

WP 4: Experimentation and deployment in function of the local territory

Main objective: The WP4 aims to consolidate the starting point for a longitudinal study[142] to evaluate of the implementation distributed strategies at a urban territorial level. WP4 is devoted to the iteration and evaluation of the urban production networks to deep understand the possible evolution according to the particularities of the urban context. As starting point, we will analyze the site and the territories concerned by the Green Fablab project, namely the urban community of "Grand Nancy" (CUGN). We benefit from the support of the municipality and the recognition of the project in the local area. We will be able to perform a field diagnosis of this territory to map and characterize the existing stakeholders needs, a SWOT analysis (Strengths, Weaknesses, Opportunities, and Threats) including technical, economic and environmental evaluations of the existing value chains, to understand where the value chain could be positioned in the future. This test is the first step to possible replicate the analysis at least in other two european territories.

Task 4.1: Participatory Workshops for a pluralistic evaluation In this task, a qualitative valuation using the pluralistic evaluation framework[**Gunton2022?**] through a living lab workshops will be made: This process has three stages: - **Step 1**: from Task 1.2, we enable us to identify relevant types of functional stakeholder along with system processes of concern to them; - **Step 2**: from Task 2.2 and Task 2.3, we will map the technical process eliciting potential judgments from each stakeholder group, to compare the centralized and distributed recycling scenarios; - **Step 3**: the resulting information is then synthesized to draw conclusions about overall relative impact of the distributed recycling system.

Task 4.2: Experimentation and validation of the System dynamics model The purpose Several case studies of distributed fabrication / recycling will be documented and developed in complement with a comparative and contextualized Life Cycle Assessment (LCA) of the new secondary AM material compared to actual materials.

3. Conceptual risk and fesability assessment

SDRAM is a high operation and conceptual-risk project mainly because the integration of multiples disciplines in a one basis framework need to establish boundary objects to have a coherent framework.

Table 4: ss

ID	Risk items	Effect of the risk	Causes of the risk	Grade	Actions to minimize the risk
1	Difficulty to data access to local territorial diagnosis	Constraint to define WP1		Middle	There have been pre-exists between the partners and these territories and recycling actors.
2					
3					

Table 5: Feasible challengues in the methodology

ID	Main challengues	Feasibility
1	Theoretical baseline on urban value chains	
2	Maturity level and technodiverstity level of the open source appropritte technology	
3	Pluralism (e)valuation of the distributed recycling systems	
4		

5. Resources and budget

The project will be hosted by the Équipe de Recherche de Processus Innovatifs (ERPI) of Université de Lorraine (UL), in Nancy (France). ERC funding will be necessary to consolidate my research team ERPI and, but also the european and international partners that I have been working on. Therefore, the funding will serve to enroll: three Ph.D. students (36 p.m. for each). (PhD1) with strong basis in urban metabolism and territorial analysis , open source hardware and systems analysis (PhD2); and ecological economics and system dynamics modelling (PhD3).

Additionally, three post-doctorate researchers (24 p.m. for each PostDoc) having a solid background on environmental science and technology with particular emphasis on urban and industrial ecology (**Postdoc1**), and quantum chemistry calculations (**Postdoc2**) and strong skills in qualitative approach (**Postdoc3**). The planning of their activities is summarized in Fig. 8 and detailed hereinafter.

PhD1 will devote a part of the first two years of his doctoral studies on the consolidation of urban the development of the thermodynamic models and of the computational tool (WP1). At the end of S1, this tool will include, at least, the preliminary simplified models needed to start with task 2.a, which aims to define thermodynamic criteria needed to select thermodynamically suitable reactions in the next phase (2.b). During S2 and S3, PhD1 will work on this task (2.a) of WP2 and, during S3 and S4 he will finalize the thermodynamic computational tool, including real fluid equations of state. In S3, PostDoc1 will start developing the procedure of task (2.b), aimed to search and to design reactions fulfilling the thermodynamic criteria provided by Ph.D.1 at the end of S3. This activity will take 3 semesters (S3-S5). In S5, Dr. Olivier Herbinet, associate professor at UL and affirmed expert developer of kinetic models of gas-phase reactions both by quantum chemistry calculation and experimental techniques, will provide his expertise in setting up, with PostDoc2, the activity of prediction of kinetic models by quantum chemistry calculations (task (2.c)). PostDoc2 will devote 2 years (S5-S8) to the prediction of the kinetics of the thermodynamically suitable reactions. However, quantum chemistry - automatized- calculations will take time. This is why, in parallel to this activity, PostDoc2 will work on task (2.d), aiming to thoroughly analyse the thermodynamic, kinetic, environmental and safety characteristics of the reactions that are gradually selected in task (2.c). PostDoc1 will also contribute to this task, working over the analysis of the environmental and safety characteristics of those reactions. PhD1 will spend the third (and last) year of his thesis (S5, S6) working over the same task, specifically in charge of the thorough analysis of the thermodynamic properties of screened reactions by means of the predictive thermodynamic tool that he contributed to develop in WP1. In S5, PhD2 will start his activities in REACHER, working with PhD1 in the thermodynamic analysis of fluids. In this period, he will acquire the expertise in using the thermodynamic tool developed in WP1. That tool represents a key input to the development of WP3, on which PhD2 will conduct his thesis. Indeed, along 5 semesters, he will work on the process and product design step, and on the assessment of the impact of kinetics on system's performances. At the beginning of his activity (in S5 and S6), PhD2 will also contribute to the design of the experimental cycle (task (4.a) of WP4)). In parallel, Dr. Philippe Arnoux, environmental engineer and assistant researcher at LRGP and expert in spectroscopy measurements, will assist PostDoc3 in the calibration of the spectrometer that will be acquired. P. Arnoux is an employee of CNRS ("Centre national de la recherche scientifique"); CNRS will be thus a Linked Third Party in REACHER. In S7, PostDoc3 will both work on the realization of the power cycle (WP4 (4.a)) and on the calibration of the spectrometer. He will finally conduct the experimental campaign, between S8 and S10.

The research team

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

As for me, I will dedicate 42 p.m. of my work to manage this five-year exciting project. I will manage each phase of the project, in the full awareness of the responsibility that I will have in its successful realization, which highly depends on my capability to -humanely and scientifically-conduct, coordinate and supervise the activities carried on by the scientific team.

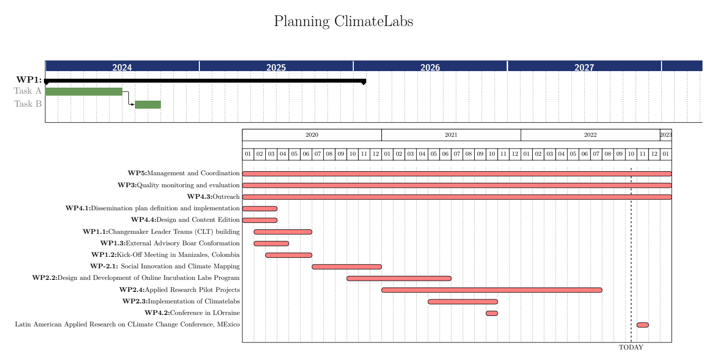

Figure 4: Gantt diagram and task allocation

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