# Section a: State of the art and objectives

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| DRAM in a nutshell |
| The main purpose of this project is to develop a breakthrough and still unexplored methodlogy to systematic Practically, the  of Systemic Distributed Recycling for Additive Manufacturing (SDRAM) is to establish a blueprint methodology for the implementation 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

In the current world, value creation chains of industrial products are often globalized. The mass manufacturing systems requires materials as well as human and physical capital to produce goods and is understood as a deep transition[1](#ref-kanger2022). That means a complex co-evolution of single unit productions systems, interconnected systems, and industrial modernity that have been gradually intensified various forms of environmental degradation[**ref?**](#ref-ref). Plastic waste contamination[2](#ref-de-la-torre2021), climate change[3](#ref-stoddard2021), biodiversity loss[4](#ref-hermoso2022) are some examples of those degradations qualified as *wicked problems* characterized by their complexity, interdependence and contextual specificity[5](#ref-Zivkovic2018). These elements are majors markups of what is recently disscused as the Anthropocene era[6](#ref-steffen2018),[7](#ref-steffen2011). The anthropocene frames the humans not only as biological but as geological force acknowledging the new status of humanity given the different indicators in the natural ecosystems that are impacting the stability of the earth system. The globalized mass manufacturing paradigm are leading to the transgression of the planetary boundaries[8](#ref-ONeill2018)–[10](#ref-Rockstrom2009), thus design of new socio-technical configuration productive systems is needed.

Dans ce programme de recherche, nous souhaitons aborder la gestion durable des ressources avec une approche holistique qui couvre l’ensemble de la chaine de valeur du matériau au produit fini et la mise en œuvre du concept d’économie circulaire permettant d’optimiser la chaine d’approvisionnement de façon durable. Pour cela, du fait de la transdisciplinarité de l’économie circulaire, nous souhaitons rassembler diverses communautés issues des géosciences, des procédés, des sciences de l’environnement, des sciences des matériaux, des sciences économiques, de gestion et de management. En particulier, nous chercherons à apporter une vision systémique de la chaîne de valeur des matériaux nécessaire à la transition énergétique et environnemental en nous intéressant à chaque étape de la chaîne de valeur, aux acteurs de la chaînes de valeurs et aux nombreuses interactions et interfaces définissant cette chaîne de valeur dans le cadre de l’économie circulaire. Nous étudierons les liens existants entre ressources primaires (mines) et ressources secondaire (résidus miniers, recyclage) afin de répondre aux notamment aux questions suivantes :

The entry of the circular economy concept in the policy[11](#ref-EC2015), industrial[12](#ref-EllenMacArthurFoundation2015) and scientific[13](#ref-nobre2021)–[15](#ref-Schoggl2020) arenas as an umbrella concept, but also as a contested one[16](#ref-CalistoFriant2020)–[18](#ref-corvellec2021), is bouleversing the design process to make clear that the ecological systems do not have nearly endless capacity to provide resources and adsorb wastes. Particularly, the urban development and engineering science needs to integrate that the externalities[19](#ref-zhen2021) of human activites’ impacts on the earth systems since the fuzzy front-end phase of the design process. 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” [Barles, 2017]. Indeed, cities worldwide are committed to becoming more circular in their resource use, but whether or not their actions help them to reduce their environmental impacts is unclear.

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. Although the origins of this concept seem to go back to the 19th century, territorial metabolism was first developed by engineers, chemists, biologists and ecologists such as Eugene Odum, Paul Duvigneaud and Abel Wolman. The latter was the precursor of an accounting approach to the inputs and outputs of flows necessary for the functioning of urban spaces in the 1960s.

Nowadays, studies of metabolism tend to develop in a sustained manner, both in the academic and institutional worlds. Most of them are conducted in the form of material flow analyses, the most widespread and solid accounting method at present.

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 wellbeing and room for innovation. At the same time, there is a sense that ‘circular economy concepts are more often celebrated than critiqued’ (Geng et al 2019).

Without adequate

monitoring tools and a basis for prioritizing, cities could be investing their limited organizational, financial and human capital on circular strategies that might not minimize the pressure on natural resources. In fact, academics have repeatedly pointed out the lack of a homogeneous monitoring framework for the circular economy (e.g. Helander et al 2019, Moraga et al 2019).

The development of polymer materials has allowed the manufacture of a wide range of low-cost, low weight, high performance products and it has become in a core part of technological and societal development [1]. The plastic industry is almost completely dependent of fossil oil and gas, using about 4% of worldwide oil production which it is translated in approx. 299 million metric tonnes per annum in the year 2012 [2]. One of the main concerns is the environmental impact of plastic residues because the longevity in the environment is not known with certainty. Most of the polymers manufactured today will persist for at least decades (if not millennia) [3]. Recycling processes (mechanical and feedstock recycling) of plastics are methods for reducing environmental impact and resource depletion. From the energy and environmental perspective in waste-management issues, it is well demonstrated the better performance of recycling scenarios with respect to landfilling or incineration options [4, 5]. In particular, mechanical recycling which entails the production through physical means of new plastic products from plastic waste [4, 6]. However, the difficulties of this process are mainly related to the degradation of recyclable mate- rials, heterogeneity of plastic wastes and the logistic related to the process [7]. In fact, in the case of U.S. only 6.5% of the used plastics are recycled in conventional centralized recycling [8]. In the case of Europe, only 26% equivalent to 6.6 million tonnes in 2012 of post-consumer plastic wastes were recycled [2]. The main reasons for the low rates of recycling plastics are related to the challenges of collection and transportation because of the high volume-to-weight ratio of the polymers. There is no net economical benefit from recycling plastic materials [9].

The scheme in Figure 5 shows an industrial ecology for polymers, that is, how different forms of plastic waste treatment are related to the production cycle [26]. There are four strategies in order to recycle plastic materials [27]: Reuse: It refers to reuse of the plastics objects after a process of cleaning. - Mechanical Recycling: The plastic is ground down and then reprocessed and compounded to produce a new component that may or not be the same as its original use [28]. - Chemical Recycling: the polymer waste is turned back into its oil/hydrocarbon component in the cases of polyolefin’s and monomers in the case of the polyesters and polyamides, which can be used as raw materials for new polymer production and petrochemical industry, or into the pure polymers using suitable chemical solvents. [29] - Energy recovery: It involves complete or partial oxidation of the material, producing heat, power and/or gaseous fuels, oils and chars besides by-products that must be disposed of such as ash. [27] In the context of this research, we are interested in the mechanical recycling. Specifically, the recycling of Polylactic Acid (PLA) thermoplastic in order to be used in the open source additive manufacturing context. To study the recyclability of the polymeric materials, it is a well-tried practice to simulate the degradation of the material by doing multiple extrusions in order to find the durability or service life, accelerating thermal and hydrothermal ageing. These methods make it possible to assess the effects of thermal, hydrothermal and thermo-mechanical degradation [30].

The convergence of information and communication technologies (ICT) with digital fabrication capabilities of Additive Manufacturing (AM), specifically the development of open source 3D printers, is creating the appropriate knowledge-based social environments that enable independent production of modular hardware. This synergy could be transformed into a new disruptive paradigm of means of production for modular hardware[20](#ref-Kostakis2013). 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. It provides the possibility of mass diffusion of this technology, and consequently, AM is being recognised as a revolutionary technology that could up-end the last two centuries of approaches to design and manufacturing with profound geopolitical, economic, social, demographic, environmental and security implications[**Economist2012?**](#ref-Economist2012)

With the expiration of Fused Deposition Modelling (FDM) patents[24](#ref-Crump1988) in the mid-2000s, Adrian Bowyer envisioned the concept of self-replicating machines, capable of manufacturing their own parts by themselves, and so simple and easy that anyone would be able to build them[25](#ref-Jones2011),[**Bailard2007?**](#ref-Bailard2007). This was the start of the *RepRap* project (or **Rep**licating **Rap**id-prototyper). RepRap is a low-cost desktop rapid prototyper which manufactures approximately 57% of its own mechanical components (excluding fasteners, bolts and nuts). This project has been developed using an Open Design approach in which detailed information on the technical design and operations of the device is publicly available on the internet. In the literature, RepRaps have been proved to be useful tools in fields such as transport[21](#ref-Birtchnell2013a), education[26](#ref-Science), engineering[20](#ref-Kostakis2013),[**Bailard2007?**](#ref-Bailard2007), tissue engineering[27](#ref-DeCiurana2013), chemical reaction wire, customising scientific equipment[28](#ref-Zhang2013)–[30](#ref-Ter2014), electronic sensors[31](#ref-Leigh2012a), wire embedding[32](#ref-Bayless2010) and appropriate technology related for sustainable development[33](#ref-Pearce2010).

Characteristics of the RepRap project, such as its open source nature and its customisation and self-replication capability, open up the possibility for exponential growth for both products and 3D printer systems. The RepRap project has been an object of social experimentation, creating numerous enthusiasts and communities interested in supporting various RepRap models. Different parallel open source systems have emerged, such as FabAtHome 3D printer[34](#ref-Malone2007), the CupCake CNC and Thing-O-Matic 3D printers by MakerBot Inc[**MakerBot?**](#ref-MakerBot) and others. The RepRap website invites machine developers to register their project in a database in order to collect the total of different prototypes and projects. According to this database, there are approximately 500 models[35](#ref-Re2014). This exponential growth makes it essential to evaluate the capabilities of machines in order to characterize and differentiate them. In fact, attention has been drawn to the relevance of logical evaluation tools for individuals to allow a fair comparison of the performance of a given unit to another through the use of a benchmarking process[36](#ref-Roberson2013),[**Perez?**](#ref-Perez).

### Major long vision: Circular and convivial production

Today, a major societal issue rely on how to conceived socio-technical ‘circular units’ for manufacturing that integrates values of sobriety[**ref?**](#ref-ref), resilience[37](#ref-touriki2021),[38](#ref-VanFan2019), adaptability[39](#ref-weichhart2021) and evolutive in urban settlements. 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[40](#ref-kallis2018),[41](#ref-savini2021). 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[42](#ref-Bakshi2018),[43](#ref-Bakshi2019a). 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[41](#ref-savini2021). Urban cities will be responsible for non-negligible environmental impact[44](#ref-Zheng2020),[45](#ref-Sodiq2019), producing about 50% of global waste, and 75% of greenhouse gas emissions which affects the sustainability of cities[46](#ref-schraven2021) and the quality of city life[47](#ref-Riffat2016).

### 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[48](#ref-Herrmann2020),[49](#ref-juraschek2022) with decentralized and distributed characteristics[50](#ref-priavolou2022),[51](#ref-cerdas2017). Aiming at a *‘design global / manufacturing local’*[52](#ref-Kostakis2018) seems a proto-industrialization[53](#ref-sabel1985) transition that is taking place in urban settlements that could a major impact in the next short future. The Open Source Appropriate Technology (OSAT)[33](#ref-Pearce2010) and peer-to-peer (P2P)[20](#ref-Kostakis2013) approaches have been seen potential drivers to propose an alternative globalisation manufacturing paradigm[54](#ref-Heikkinen2020a). The open source (OS) approach has become well-established to provide improved product innovation over proprietary product development[55](#ref-dibona1999)–[58](#ref-deek2007). The evidence is most mature for software development because free and open source software (FOSS) provides: i) diversification and open innovation[59](#ref-colombo2014)–[61](#ref-alexy2013), ii) cumulative innovation[62](#ref-boudreau2016), iii) development efficiency[63](#ref-hienerth2014), iv) organizational innovation[61](#ref-alexy2013), v) higher technical quality of code[64](#ref-soderberg2015), vi) encourages creativity[65](#ref-martinez2015) and vii) perhaps most importantly, it avoids redundant work[66](#ref-Ardal2016). The OS approach is now also gaining traction in free and open source hardware (FOSH)[67](#ref-thompson2011)–[71](#ref-li2018) and appears to be roughly 15 years behind FOSS in development and adoption[72](#ref-pearce2018). 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[73](#ref-petch2014)–[76](#ref-wittbrodt2013). The open source additive manufacturing technology, also know as 3D printing, have played a major role in the idea of democratization of manufacturing means[77](#ref-Beltagui2020). Thousands of open-source products are shared by the global community from consumer goods to scientific[78](#ref-Pearce2020a) and medical equipment[78](#ref-Pearce2020a),[79](#ref-He2014). This model has been proven to be effective for emergency manufacturing during the COVID-19 pandemic[78](#ref-Pearce2020a),[80](#ref-tan2021). 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[48](#ref-Herrmann2020),[81](#ref-Ijassi2022).

### Distributed recycling for additive manufacturing: a promising inclusion

Since 2014, I have been working on the validation of the open-source 3D printing, filament-[82](#ref-CruzSanchez2014) and pellet-based[83](#ref-Arthur2020), as a robust manufacturing system, but also as a potential enabler of the mechanical recycling[84](#ref-Cruz2015)–[86](#ref-lopez2022) of plastic waste feedstock. Likewise, I have been working on the design of the pertinent closed-loop supply chain[87](#ref-Pavlo2018),[88](#ref-Santander2020), considering the applicable sustainability indicators[89](#ref-Santander2022) based on the scientific literature. In a recent paper[90](#ref-CruzSanchez2020), I could highthligh a great interest by the scientific community of this topic which is called *distributed recycling for additive manufacturing (DRAM)*. DRAM (See [Figure 1](#fig-DRAM)) 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.

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| Figure 1: Distributed recycling via additive manufacturing. Source |

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 (FFF), which is a material extrusion process [@]. DRAM starts with waste plastic 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 FFF can be manufactured economically using distributed means with a waste plastic extruder (often called a “recyclebot”)[91](#ref-Baechler2013) for mono or composite 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 Amazon.com. Fused granular fabrication is a recent experimental approach enabling the printing process directly from pellets[92](#ref-JustinoNetto2021),[93](#ref-netto2022), which reduces the degradation cycles of the plastic. For this process, I worked in the desktop format[83](#ref-Arthur2020), but it seems that this technology could further expand the boundaries of additive manufacturing and eventually recycling[94](#ref-billah2021)–[96](#ref-Byard2019) for larger object[97](#ref-petsiuk2022). Distributed recycling fits into the circular economy paradigm[98](#ref-Zhong2018)–[100](#ref-Despeisse2016), 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[101](#ref-Kreiger2013)–[103](#ref-Horta2017). Additionaly, open-source investment should result in an extremely high return on investment (ROI)[78](#ref-Pearce2020a). This makes distributed recycling environmentally superior to other methods of plastic recycling systems.

However, I realized that the global system maturity is ambiguous given that not all the value chain for the implementation of a community-driven of plastic recycling are matured[90](#ref-CruzSanchez2020). 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 important, the analysis of the holistic impact that this process can have in the context of a city remains not well understood. In the framework of a EUH2020 project called INEDIT[[1]](#footnote-30), I have been leading the implementation of the *Green Fablab* demostrator inside the third place called Octroi-Nancy Association [[2]](#footnote-31) since November 2021[[3]](#footnote-32). INEDIT project aims to create an ecosystem to transform the *Do-It-Yourself* 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 demostrator that that use living lab approach[104](#ref-tyl2021),[105](#ref-compagnucci2020a) 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[106](#ref-Ceschin2016). 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 recycled resources industry (RRI) is starting to conceived inside the cities[107](#ref-wang2019b). 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 . The sustainable development of the RRI has thus been highlighted on many countries’ agendas to promote the circular society[108](#ref-leipold2021)–[110](#ref-jaeger-erben2021a), as well as the goals of carbon peak and carbon neutralization. In the case of plastic waste, the main difficulty remains to make affordable the use of new secondary material applicability by the industry[111](#ref-klotz2022), but more profoundly, how these socio-technical experiments will interact with the urban planning and polycimaking to make concrete the ambition of circular economy inside the urban and regional settlements.

## 2. Ambition & objectives

The material rarefaction[112](#ref-hultman2021), the ecological integration of manufacturing systems[43](#ref-Bakshi2019a),[113](#ref-Bakshi2015),[114](#ref-Saladini2018) and the urban resilience[115](#ref-xu2021e) calls for pushing forward the boundaries of knowledge of the urban production systems to unleash a sustainability transition towards circular economy. Therefore, the main objective of this project is **to establish a systemic methodological blueprint to fully understand how to design, implement and (e)valuate an open source distributed manufacturing/recycling production systems for an urban values chains inspired on the “Design Global / Manufacturing local” principles**. The deployment of circularity marks a return to a more productive conception of the city, that must consider the natural and urban ecosystem services, the strength the resilience capacities and take 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 distributed production/recycling systems as a circular economy strategy in urban settlements. 2) Holistic and pluralistic (e)valuation of the pertinence of the open source appropriate technologies, practices and potential innovation as an assets for urban territorial development. Table XX presents an outline of the three major layers to consider in these project.

| **Challenge 1: Urban system essential role in the deployment of the circular economy.** |
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| In order to identify the design process of an urban circular production system, some relevant questions are the following:   * What are the acceptability conditions for the deployment of urban demostrators of circularity ? * How to establish the link to integrate territorial planning priorities with respect to production systems priorities within an urban circular economy context? * How to dimension production systems to be consistent with the resources and materials (first and second hand) considered as local? * How to identify the opportunities and barriers from a social, technological, political and legal point of view for the implementation of an urban production 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? * How would the implementation of urban production systems affect the functional blocks of an urban territory? |

| **Challenge 2: Open Source technodiversity as territorial asset.** |
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| 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 and circular production? * 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 circular and urban production systems.** |
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| In order to (e)valuate in a pluralistic way the development and implementation of urban production 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 considerations the necessary to represent the preferences of the stakeholders in the decision-making process of integration urban / manufacturing systems? |

# Section b. Methodology

## 3. Introduction the scientific methodology

SDRAM implement a methodology made of four working packages (WP), as illustrated in Fig. . The aim of WP1 is to set a literature baseline for an integrative and critical analysis of urban territory in the frame of micro-value chains for local recycling loops. 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 recycling process establishing an unit maturity level index for each, but more important, a system maturity level for the integration in a urban ecosystem. The main goal is to establish a complete OSAT 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, resiliency, and agility into a circular economy praxis. Finally, WP4 is dedicated to the experimentation of the several products case studies of the urban circular manufacturing taking 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 in other territories such Chile, in collaboration with Prof. Pavlo Santander, and in Canada with collaboration of Joshua Pearce. Work packages are synthetically detailed hereinafter.

### WP 1: Theoretical baseline on urban value chains

WP1 aims at developing a integral methodology to diagnose, quantify and evaluate the potential urban value chains for distributed recycling loops on a territory considering the ecological priorities of the territory. The achievement to SDRAM target relies the urban spatial analysis and stakeholders characteristics as an entry point of the design of the socio-technical system mapping two major outputs: 1.1) The first output aims to highlights: (a) the identification of the priorities in terms of ecosystems services of the territory at the urban planning level, and how the plastic waste affects them. (b) the evaluation (technical, economic and environmental) of the current waste management system to identify the ’ of the limits of the loop chains , existing plastic ‘gaps’ that distributed recycling approach can fill, and (c), a stakeholder characterization analysis needs (e.g. sorting centres, recycling centres, schools). Then in 1.2), the second output aims to close the existing data gaps[116](#ref-Bianchi2020) in terms of secondary material availability at the urban level considering its complexity level of revalorization. The goal is to couple *{territory x material}* together as a material flow quantitative analysis to assess the potential to material for a closed-loop supply chain. This is particularly relevant in the context of plastic products where governments worldwide are placing ambitious circularity targets due to the accumulation. The priority is to reveal a list of ‘suitable’ secondary plastic materials wastes at the urban level that today are not fully understood and valorized. This analysis will be carried out 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.

### WP 2: Maturity level and technodiverstity level of the open source appropritte technology

The WP2 will be focused on the unit- and facility-level to better understand how OSAT can be implemented in urban micro-recycling systems. The main purpose of this task is to leverage a resilient manufacturing[115](#ref-xu2021e),[117](#ref-zhang2011) under the logic of Design Global/Manufacture Local robustness. To do so, three major tasks are seen:

2.1) definition of a scientific literature and critical analysis on the adoption[118](#ref-reinauer2021) and barriers of the open-source appropriate technologies with particular focus on distributed recycling considering the modularity types[119](#ref-gavras2021), gaps in the hardware development and .  
2.2) Mapping of new/adapted practices and tools that would be needed to support local manufacturers and local decision makers to navigate and overcome the challenges of distributed recycling manufacturing. 2.3) Identification a system maturity level that enable the constitution of urban closed-loop supply chain . …

### WP 3: Pluralistic (e)valuation of distributed recycling systems

In parallel of WP2, the WP3 aims to consolidate aid-decision tool to reveal and better understand under which conditions these distributed recycling/manufacturing urban chains are pertinent for the local territory. This tool describe and characterize the new value chain to include new form of pluralism valuation[120](#ref-gunton2022) and techno-ecological interactions[114](#ref-Saladini2018),[121](#ref-Liu2020c),[122](#ref-Liu2019g). More important to avoid Jevons paradox[123](#ref-giampietro2018), it is determine the scale of action considering the technical maturity, economic viability and environmental respect of the ecosystem services. In (4.1), one strategical point in sustainability relies on explicitly account for their demand and supply of of ecosystem goods and services framework given by the micro-value chains[124](#ref-Diwekar2021). then (4.2), the main aim is to reveal the components and the structure of the urban circular networks to the combining Material Flow Analysis[125](#ref-saidani2021), System Dynamics[126](#ref-kuo2021)–[130](#ref-perez-perez2021) and Circularity Indicators[131](#ref-saidani2019).

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

The WP4 aims to consolidate a starting point for a longitudinal study[132](#ref-langley2013) to evaluate of the implementation these distributed recycling strategies at a urban territorial level. WP4 is devoted to the iteration and evaluation of the urban production networks to deep understand the evolution. 4.1) 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. 4.2) A strategic roadmap will be a major delivered to understand the possible evolution of

To pass from ecodesign to an operation design for sustainability approach, this WP4 will be based ten different models at operational, tactical, and strategical levels[133](#ref-SousaRocha2019).

## 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 object to have a coherent framework.

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| 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 |  |  |  |  |  |

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 |  |  |

## 4. An Impact project

* **Main scientific impacts.** (1) the breakthrough understating of the implementation and evaluation of the design of sustainability of socio-technical systems
* **Main societal impacts.** If the expected modeling are confirmed, the outcome of this pproject will allow urban and technical desicion-makers the implementation of local recycling circuits of available plastic waste by means of small, ro distribed recycling socio-technical units.

## 5. Resources and budget

### 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 %). %

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1. See https://cordis.europa.eu/project/id/869952 [↑](#footnote-ref-30)
2. See https://www.octroi-nancy.fr/ [↑](#footnote-ref-31)
3. This demostrator found retard because of the pandemic situation. [↑](#footnote-ref-32)