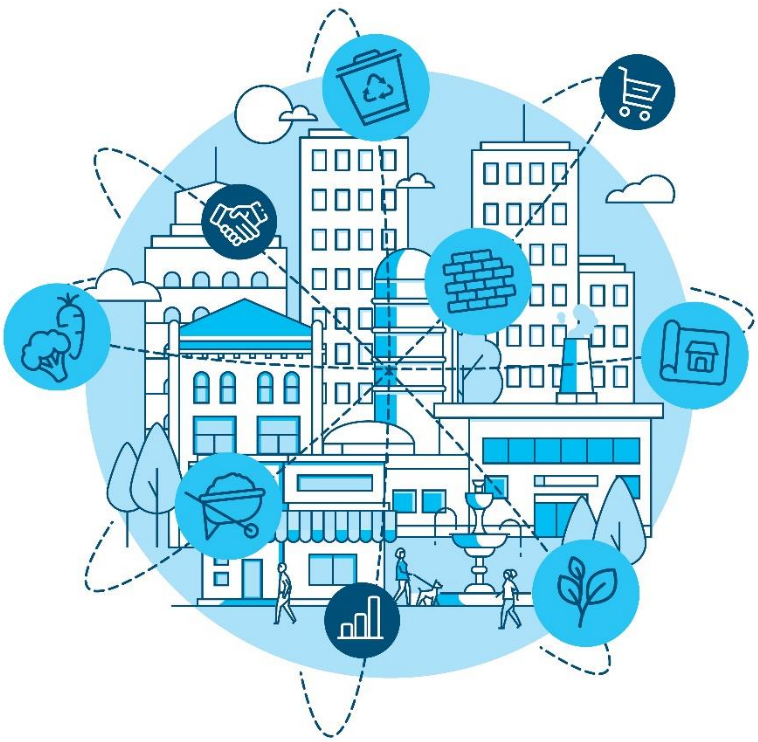
Bio-waste valorisation decision tool

Wageningen Research



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Contents

1. Introduction

In this document a tool is described aimed at helping cities to choose between all possible valorisation options for bio-waste streams. The tool uses the viewpoint of a city employee in charge of selecting the valorisation routes for bio-waste that is collected. In a city all kind of viewpoints are present. People focussing on maintaining and improving the public spaces, people focussing on starting new business, people looking for cheap biomass, etc. All these people will have different ideas on the optimal valorisation options. The tool can help to select between all the options that are present, while keeping in mind the policy of the city on circularity and the overall well being of the citizens. After the selection the valorisation options can be tested or demonstrated, by the city itself, or e.g. by companies after circular procurement.

This tool aims to help cities to choose between all kind of possible valorisation options for bio-waste prior to deep diving into all the details of a circular valorisation option. The examples given in the tool focus on the bio-waste from green spaces, however it can be used for other bio-waste streams as well.

During the preparation phase of CityLoops a selection of four different valorisation options was made to demonstrate in Apeldoorn. The selection process was based on a set of parameters, ideas, and dreams of a future circular city regarding bio-waste and public spaces. Current practice of Apeldoorn in selecting valorisation options prior to Cityloops was to start with initiatives that looked attractive, without looking at the initiatives from all perspectives.

2. Tool description

The input for the tool consists of four distinct factors:

- Factor I: Policy goals of the city.
- Factor II: Circular economy principles.
- Factor III: Parameters of the bio-waste.
- Factor IV: Parameters of possible converting processes.

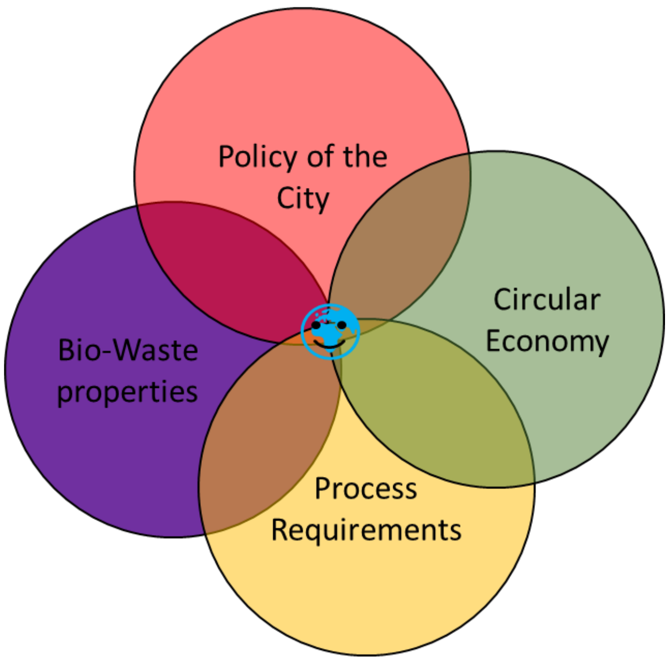

Figure 1 Combination of the different groups will result in a choice for valorisation options

A valorisation option (e.g. Produce birdhouses in a social workspace setting from wood of trees that are removed.) can be graded on the four factors. How well does the valorisation option fit into the city policy. is the valorisation option contributing to the circular economy or does it take bio-waste out of the circular economy (paints and glues may turn wood into chemically polluted waste only fit for burning). Are the bio-waste properties in line with the required properties (e.g. Is the wood strong enough. Is the envisaged production process capable of transforming the bio-waste into the desired product and is e.g. the scale of the production process fitting to the amount of bio-waste present.

2.1. Factor I: Policy goals of the city.

The overall goal of CityLoops is “To better understand how local governments can best promote the transition to a circular economy (CE) in their city. Closing urban material and resource loops, and thereby reducing the environmental footprint, increasing regenerative capacities, and stimulating new business opportunities.” Cityloops decided on a definition of circular cities and connected the progress towards becoming a circular city with the global development goals. [Cityloops D6.1]

Specific cities however will have their own policies towards circularity and may focus on other topics. In e.g., Apeldoorn the focus of the city was for the last years on the Energy Transition rather than circularity, but as with all municipalities focus is subject to political and private sector influences over time.

Creating an overview of the policies and practices of a city regarding the circular economy and bio-waste will help to decide which valorisation options to select.

2.1.1. Situation of Apeldoorn

Currently in Apeldoorn decisions on the management of bio-waste from public spaces, are made by the cities department of “Management and Maintenance of public Spaces”. Priorities centre on maintaining and improving the quality of the public spaces. Initiatives from other departments on circularity are minimal, because of lack of political focus on circularity. Although the Apeldoorn policy is not focussing on circularity, several initiatives connected to the biobased economy and the inhabitants are actively supported by Apeldoorn:

- The cultural centre of Apeldoorn CODA, with a library, museum, archive nd ExperienceLab. CODA is a source of inspiration in the field of literature, art and heritage – right in the heart of the city. Discover the most beautiful stories, experience the history of Apeldoorn and the Veluwe, taste art and culture, find what you are looking for and be surprised by what you were not looking for. Coda has regular exhibitions on paper and 3 D printing, and CODA ExperienceLab consists of a Showroom in CODA Museum and various innovation labs in the Makerspace in CODA Library: with recycling hubs in relation to fashion and plastic (e.g. 3D printing), a BiodesignLab, VR Lab.
- The oldest paper mill of the Netherlands “De Middelste molen” is a working papermill and museum located in Apeldoorn, next to an industrial region (Community of Apeldoorn and Eerbeek) with several papermills and paper companies, the largest biobased industry in Apeldoorn

2.2. Factor II: Circular economy principles.

Circular economy is an umbrella term used to convey and promote improved activities which at the practical level may refer to many different processes. Such as reuse of materials, returning nutrients to the environment, preventing plastic waste, moving away from a fossil oil-based society are all possible achievements that are referred to as part of the circular economy. Three different models were used in the decision tool to describe (parts of) the circular economy:

- The butterfly model of Ellen MacArthur.
- Waste hierarchy, ladder of Lansink.
- The biobased value pyramid.

The butterfly model of Ellen MacArthur

The butterfly model describes the circular economy as consisting of two circles, one focussing on finite materials (blue) and one on renewables (green). Bio-waste is part of the green cycle.

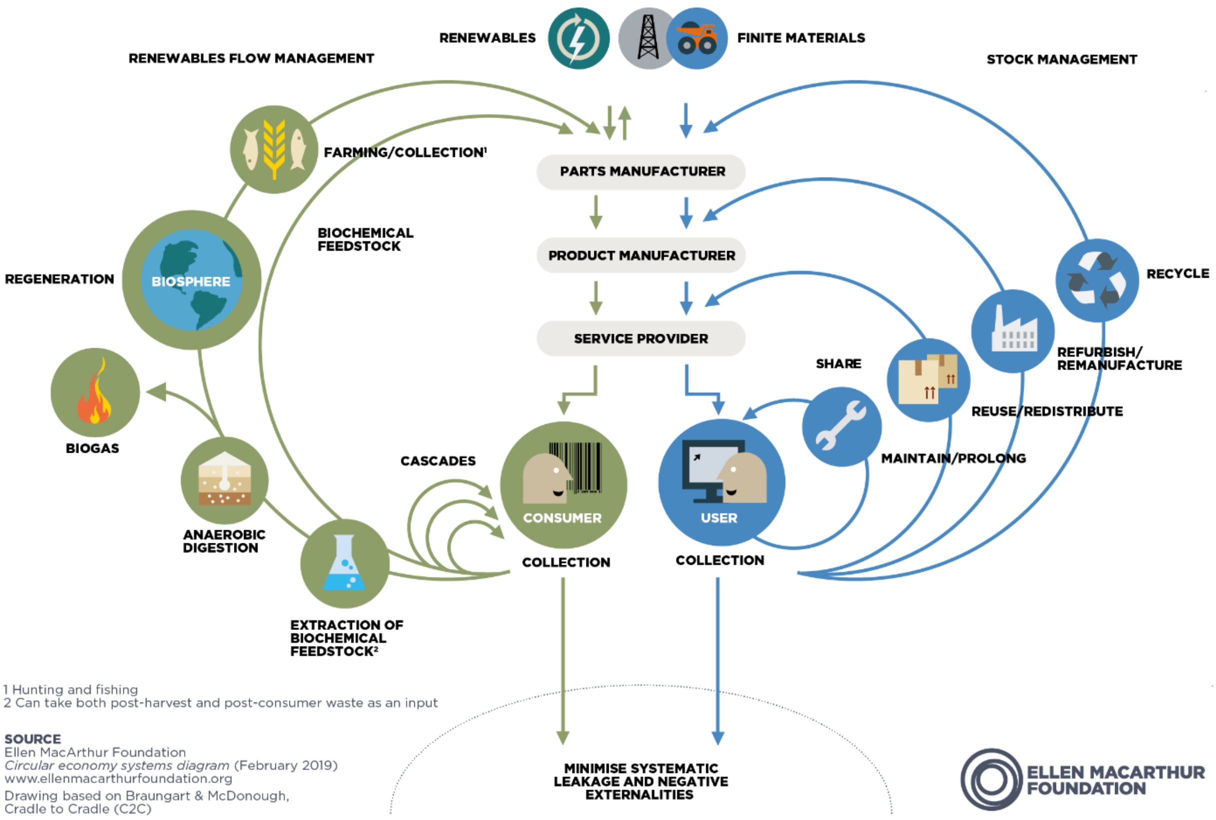

Figure 2 Butterfly model, Ellen MacArthur circular economy systems diagram

All parts of the circles should be considered, the model shows that products made from biomass after use by consumers can be reused several times by consumers directly (cascades) or after a second manufacturing step. This “reuse” of products is thereby used in a separate way of the “reuse” of finite materials, where the terms share, maintain, prolong, reuse, redistribute, refurbish, remanufacture, and recycle are used. Most importantly for used products from renewables as bio-waste there is the option to regenerate the biomass by returning the nutrients and CO_2. to the biosphere. Here additionally the options to create bio – energy and extracting bio-chemicals are positioned.

The butterfly model does not specifically describe bio-waste from green spaces as a resource, and without creating products or materials from the bio-waste, the processes used to maintain or improve the quality of the green spaces are part of the regeneration. The butterfly model focusses on the production of materials to be used by consumers. Leaves, pruning, grasses that are collected and used to maintain the green spaces (even after composting or the bokashi process) do not add any product, chemical or bio-chemical to the circular economy. However, it is part of the circular economy and should be part of a circular city.

Valorisation options for bio-waste from green spaces will validate how current practices in Apeldoorn can be illustrative of a move towards more circular practices through public-private partnerships or develop practices that are reflective of the butterfly model.

Waste hierarchy, ladder of Lansink

The Dutch politician Ad Lansink designed a waste hierarchy that is used often when discussing possible options for handling waste. It was not specifically made with bio-waste in mind. It combines (but pre-dates) valorisation options from both the blue and green cycles from MacArthur.

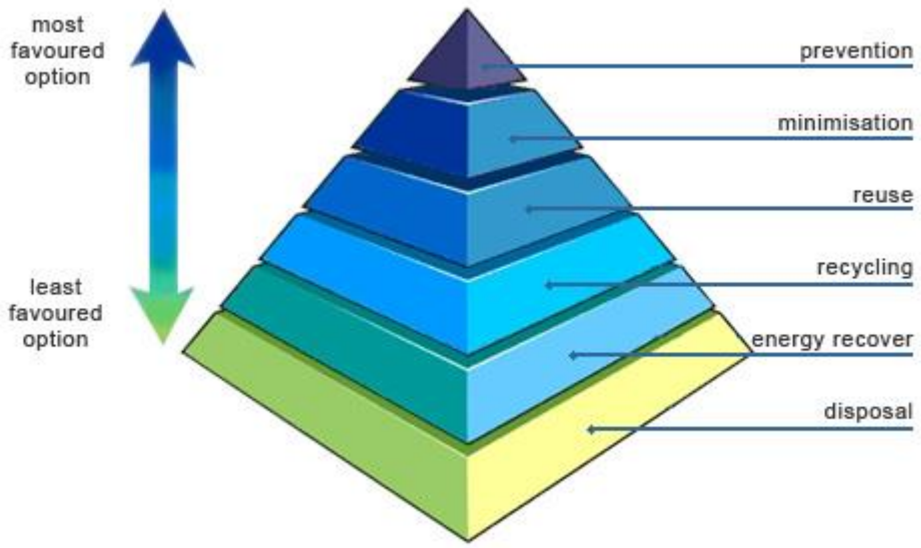

Figure 3 Waste Hierarchy [www.adlansink.nl]

On the top end, for bio-waste from green spaces both prevention and minimisation are an option. It is possible to select plants and design green spaces in such a way that less bio-waste is generated. Direct return of the generated bio-waste during pruning or removal of leaves from the streets into the biosphere for example after chipping or mulching could be used. This may be cost-effective and even improve the quality of the green spaces, but will not help in creating a circular, biobased economy. On the bottom end, disposal in landfills (e.g., because of contaminations), should be avoided at all costs. For bio-waste reuse could be thought of as creating products or chemicals from the bio-waste, as described by the green circle in the butterfly model of MacArthur. Recycling can be done directly by e.g., digestion, but ideally should be performed after the reuse stage. Recycling includes the option to recover nutrients to regenerate the biosphere. Energy recovery refers to incineration with energy recovery.

The biobased value pyramid

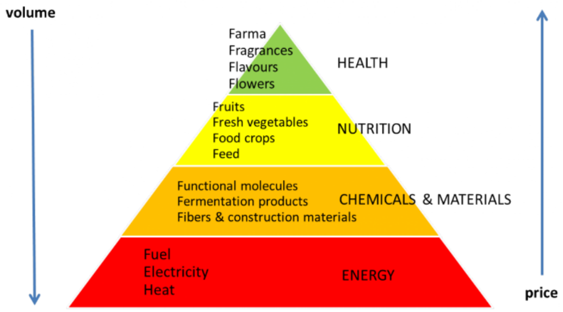

Figure 4 Biobased value pyramid [www.wikiwijs.nl]

The volume and price of biobased products are often presented as a pyramid. Most biomass is used to produce energy at low costs, most expensive products are pharma and fragrances, but volumes are low.

The biobased value pyramid can differ based on e.g., location and technical developments.

In the decision tool, the three models are used to characterise the different valorisation options. Options can be rated based on their position inside the three models.

2.2.1. The Apeldoorn situation

In Apeldoorn valorisation options were graded high if they fit into the MacArthur green circle, if they focus on reuse and recycle options in the waste hierarchy by Lansink and if they are high in the biobased value pyramid.

- **Production of bokashi from leaves**

MacArthur: Inside the green circle. After processing into bokashi the collected leaves can be returned to the green spaces and help regeneration of biomass.

Lansink: Using leaves as bokashi is an example of reuse, high up in the ladder, only prevention of bio-waste from green spaces (e.g. by selecting plants that are producing less bio-waste) or minimisation (direct return of collected leaves to the green spaces) are higher.

Value pyramid: Average, bokashi as compost is a low value (economically) material. It can be of high value to Apeldoorn in its thrive to improve the green spaces.

- **Production of biochar from pruning**

MacArthur: Inside the green circle. After processing biochar can be returned to the green spaces and help regeneration of biomass, biochar production also provides heat that can be used for heating households.

Lansink: Biochar is an example of reuse, high up in the ladder.

Value pyramid: Average, biochar from pruning as soil improver is a low value (economically) material. Upgrading from biochar into activated coal for medical purposes would be higher on the pyramid. It can be of high value to Apeldoorn when it is applied in improving the quality of the water, e.g. by cleaning rainwater after collection.

- **Production of paper from grass**

MacArthur: Inside the green circle. Paper can be recycled several times. Paper that can no longer be recycled will be returned to nature.

Lansink: Paper from grass is an example of reuse, high up in the ladder.

Value pyramid: Average, grass is considered a low value fibre for production of paper. The dutch paper industry is not ready to shift to alternative fibres for their production.

- **Production of 3D printing filament from Japanese Knotweed**

MacArthur: Inside the green circle. By using PLA as biodegradable plastic in the composite material the produced 3D printed objects can be discarded through industrial composting facilities or reprocessed into new composite materials

Lansink: 3D printing filament is an example of reuse, high up in the ladder.

Value pyramid: Average to high, 3D printing is an upcoming industry, added value of the product is high, while the volumes are still low. Factor III: Parameters of the bio-waste

Properties of the bio-waste collected in a city determine to a substantial extent the possible valorisation options. A good overview of bio-waste should contain the following parameters:

- The amount of bio-waste collected on e.g. a yearly basis.
    - Amount in tonnes wet
    - Amount in tonnes dry
- The type of bio-waste collected.
    - What (part of) plants are present in the bio-waste?
    - What is the state of the bio-waste (dried out/fresh/old etc.)?
- The availability of the bio-waste throughout the year
    - When is the bio-waste collected?
    - Can the bio-waste be stored (and how does that change the quality)?
- The composition of the bio-waste
    - What are the chemical components in the bio-waste?
    - What are the larger components in the bio-waste (e.g. fibres, protein)?
- The quality of the bio-waste
    - What impurities are present in the bio-waste (e.g. sand, plastic)?
    - How stable is the bio-waste?

The gathered information can be used to match converting processes with the bio-waste, e.g. on scale, desired components, and purity. City policies may also influence the bio-waste parameters: Apeldoorn has reduced the space for storage of bio-waste in the past years. Increasing storage space would increase costs, but also increase valorisation options.

2.2.2. The Apeldoorn situation

- The amount of bio-waste collected on e.g. a yearly basis.
    - Amount in tonnes wet
    - Amount in tonnes dry

The work done by Metabolism of Cities, partner in Cityloops, to visualise the locations inside the cities where biomass is produced, stored, discarded, and reused as bio-waste is a valuable addition to the overview of parameters of bio-waste [Metabolism of Cities, 2023]. A simplified version [Figure 5] created by Apeldoorn during the beginning of the cityloops project was used in the selection of valorisation options for Apeldoorn.

The collected numbers are on wet basis, dry numbers were not available.

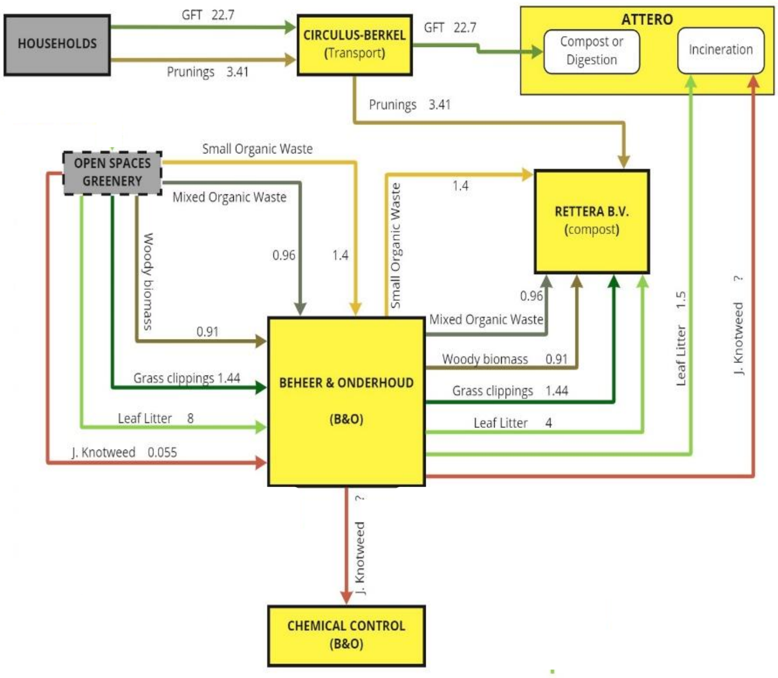

Figure 5: Overview of actors and quantities of the yearly bio- waste flows in kiloton present in Apeldoorn's biological waste system based on the final weighted mass and estimated mass for J. knotweed in 2019. Partially adapted from (Korte, 2020).

- The type of bio-waste collected
    - What (part of) plants are present in the bio-waste?
    - What is the state of the bio-waste (dried out/fresh/old etc.)?

Apeldoorn concentrated on grass, leaves, pruning and Japanese Knotweed as bio-waste materials from green spaces. Food waste and waste from households was not part of the project in Apeldoorn. Woody biomass: larger branches and trees (not pruning) were also excluded as they are part of the materials collected in a material depot already.

- Grass is harvested in two periods, in spring the grass is fresh, at the end of the summer the grass is older and dryer.
- Leaves are collected in the autumn, they are old and mostly dried out.
- Pruning is collected throughout the year, freshness will change during the year.
- Japanese Knotweed is generally mown at the end of the summer. Only stems and leaves are collected. They are mostly dried out. Roots are remaining in the ground.

- The availability of the bio-waste throughout the year
    - When is the bio-waste collected?
    - Can the bio-waste be stored (and how does that change the quality)?

- Grass is harvested in two periods, in spring the grass is fresh, at the end of the summer the grass is older and dryer. Grass will change upon storage; wet grass will start to sweat or heat. Storage of grass as hay is possible, but expensive.
- Leaves are collected in the autumn; they are old and mostly dried out. Leaves will biodegrade upon storage.
- Pruning is collected throughout the year; freshness will change during the year. Pruning is relatively stable upon storage.
- Japanese Knotweed is collected and kept separately from other bio-waste to avoid spreading of this invasive species. Storage is possible, but not preferred to avoid spreading.

- The composition of the bio-waste
    - What are the chemical components in the bio-waste?
    - What are the larger components in the bio-waste (e.g. fibres, protein)?

- Fresh grass contains mainly protein, sugars, short fibres and nutrients. Older grass contains less protein, and tougher fibres.
- Leaves contain nutrients and mainly weak biological tissue.
- Pruning is mainly wood and bark. It contains mainly lignocellulose.
- Old, dry Japanese knotweed contains mainly long fibres, soft tissue and nutrients.

- The quality of the bio-waste
    - What impurities are present in the bio-waste (e.g. sand, plastic)?
    - How stable is the bio-waste?

- Grass from green spaces will contain sand (picked up during mowing) and all kind of waste (plastic, metal). Cleaning of grass by volunteers will result in a removal of the larger contaminants, smaller pieces will still be present.
- Leaves collected from the streets will contain sand, and all kind of (plastic, metal) waste. Cleaning of grass by volunteers will result in a removal of the larger contaminants, smaller pieces will still be present.
- Pruning is rather clean; sand and contaminations can be largely avoided by collecting it directly.
- Japanese Knotweed is a clean raw material, specifically when harvested on plots that are completely covered with JK.

2.3. Factor IV: Parameters of possible converting processes

Different parameters have been used to characterise possible converting processes. An overview contains:

- Categorisation of a valorisation process based on the type of converting.

Valorisation options can be e.g. fit into handicraft, agricultural, mechanical, and chemical categories. Distinct categories are more suited into the environment of a circular city. A possible categorisation and overview on biorefinery options can be found in the Catalogue of technologies, business models and social innovations for small scale bio-based solutions. *https://mainstreambio-project.eu/wp-content/uploads/2023/05/D21CAT1.pdf*

- Scale of the process
    - Scale relates to the amount of biomass per year that is needed to run the process. General rules are used to estimate the optimal scale of valorisation options, partly based on the scale of existing processes and partly on design rules for small scale biorefineries [Bruins, 2015].
- Flexibility of the process
    - Is it possible to use multiple feedstocks in the process, thereby reducing the amount of bio-waste necessary?
    - Is year-round production necessary to create economic viability of the valorisation process?
- What is the technology readiness level (TRL) of the proposed valorisation option?

The TRL defines how much technological research is still needed prior to implementation. It can also be used to estimate the required time necessary before a valorisation option can be implemented in the city.

Table 1: Technology Readiness level [Definition used by Horizon 2020]

Technology Readiness level	
TRL 1	basic principles observed
TRL 2	technology concept formulated
TRL 3	experimental proof of concept
TRL 4	technology validated in lab
TRL 5	technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies)
TRL 6	technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies)
TRL 7	system prototype demonstration in operational environment
TRL 8	system complete and qualified
TRL 9	actual system proven in operational environment (competitive manufacturing in the case of key enabling technologies; or in space)

2.3.1. The situation for Apeldoorn

- **Bokashi production of leaves**
  - Categorisation of a valorisation process based on the type of converting.

    The bokashi process is a fermentation, but it can be performed as an agricultural process. After the initial processing involving removal of metal parts, cutting, and mixing with the effective microorganisms, the heap of leaves can be left under a cover for several months (not unlike the heaps of silage grass produced by farmers) Because of this agricultural process, processing can be performed inside the city of Apeldoorn, next to the build up area.
  - Scale of the process

    A single heap of bokashi contains about 500-1000 ton on wet basis.
  - Flexibility of the process

    The bokashi process can be used on a large variety of biomass. For Apeldoorn the collected leaves are not mixed with another biomass.
  - What is the technology readiness level (TRL) of the proposed valorisation option?

    The TRL of the bokashi production from leaves is at 7. More work is needed to show the properties of the product as soil improver. Some knowledge on the value of the process compared to composting is missing.

- **Biochar from pruning**
  - Categorisation of a valorisation process based on the type of converting.

    Biochar production is a pyrolysis process, generally performed in an industrial environment. The produced heat during the process can be used in district heating.
  - Scale of the process

    Most pyrolysis processes typically are performed at large scale. On small scale produced heat cannot be recovered and cleaning of the gasses produced during the process is relatively expensive. Apeldoorn started prior to cityloops on a project to produce biochar with a small-scale unit.
  - Flexibility of the process

    Biochar can be produced from different biomass sources; however the properties of the produced biochar are depending on the biomass sources. Mixing of biomass is therefore avoided. It is possible to process different batches of biomass after each other.

- What is the technology readiness level (TRL) of the proposed valorisation option?

  The TRL of the biochar production from pruning is estimated at 4/5. Although biochar production has been studied for a long time, using pruning as a input material on small scale is new. Properties of the produced biochar are unknown.

- **Paper from grass**

  - Categorisation of a valorisation process based on the type of converting.

  The production of paperpulp from grass can be a (bio-)mechanical or chemical process. Chemical pulping is not existing in the Netherlands, and therefore not considered. Mechanical pulping of grass is a process that can be performed next to a paperfactory.

    - Scale of the process

  Typical small scale mechanical pulping process produce 10 kton of pulp per year. Larger initiatives in the Netherlands are aiming at 40 kton of pulp per year (Newfoss). Small scale batch runs of paper at commercial specialty paper factories can produce as low as 500-1000 kg of paper per production run. Mechanical pulping processes are available at some paper factories and can be used on demand.

  - Flexibility of the process

  Mechanical pulping processes (Disk refiners) can process a large variety of biomass. Specialty paper factories may change between biomass sources between within days.

  - What is the technology readiness level (TRL) of the proposed valorisation option?
  - The TRL of the paper production from grass is at 7. More work is needed to improve the valorisation of the components of the grass that end up in the wastewater of the paper factory.

- **3D printing filament from Japanese Knotweed**

  - Categorisation of a valorisation process based on the type of converting.

  A wet, mechanical process can be used to convert Japanese Knotweed in a fibre for composite materials.

- Scale of the process

Mechanical processes to extract fibres from biomass are typically performed at 10-40kton/year.

- Flexibility of the process

The process to obtain long fibres from JK could also be used to process e.g. long hemp, flax and nettle fibres.

- What is the technology readiness level (TRL) of the proposed valorisation option?

The TRL of the fibre production aiming at long fibres from JK was increased from 1 to 4 by Cityloops. Additional work is necessary to optimise the process economically and prove the concept on larger scale. The TRL of short fibre production from biomass is at 7, several examples from different biomass sources in 3D filament exist.

For Apeldoorn it was chosen to only consider valorisation options that were estimated to be above TRL 4 to be able to demonstrate the options in Cityloops.

2.4. Other factors

The parameters of the different converting processes were used to enable the decisions between the different valorisation options. Processes should fit the policy of the City; processes could be graded on circularity principles and the parameters of the bio-waste were compared with the different processes.

Two other key factors for a circular bio-waste process are kept out of the selection. The economic viability of the process and the interest of industrial partners in developing a business.

- Economic viability

The reason for disregarding the economical viability in the tool is partly based on the overall goal of Cityloops. It is envisaged that the shift to a circular city may result in higher costs in processing of bio-waste, but will result in other (e.g., environmental, and social) benefits for the city. Disregarding the economical viability is also motivated by the “inconvenient truth” that without e.g., a CO_2 tax or a subsidiary contribution there are few biobased processes for non-food and feed applications besides the existing large-scale industries that are economical viable. Some economical factors are considered in Group IV, parameters of possible converting processes, mainly in considering the economy of scale for different processes.

Of course after the demonstration upon deciding to continue with the valorisation option, economic viability will have to be considered.

- Interest of industrial partners

The interest of existing or upcoming industrial partners in setting up a process on bio-waste was kept out of the selection tool because it is desirable that a city decides on routes towards a circular city/economy based on “neutral” data instead of being led by industry. A city should consider the values of all stakeholders rather than focussing only on industrial entrepreneurship. However, the selection tool and the distinct groups in the tool would be very useful in evaluating the ideas of interested industries.

The demonstrations are used to interest industrial partners into the chosen valorisation options.

3. Selection

As depicted in Figure 1 valorisation options that could be selected are combining the four factors.

- Factor I: Policy goals of the city.
- Factor II: Circular economy principles.
- Factor III: Parameters of the bio-waste.
- Factor IV: Parameters of possible converting processes.

During the selection process valorisation options are assessed one by one on the different factors. The policy goals of the city (factor I) and the parameters of the available bio-waste (factor III) can be determined independent of the valorisation option considered. The score of the valorisation option towards the circular economy principles and the parameters of the possible converting processes will need to be determined for every valorisation option. In practice the process will partly be iterative: For example, when it is observed that a certain process requires a continuous availability of biomass (factor IV), the possibility of storing biomass can be re-evaluated in parameters of biowaste (factor III). It may be necessary to consult experts on biobased process and biobased materials.

3.1. Selection in Apeldoorn

The selection process in Apeldoorn was performed in cooperation with Wageningen Research.

As described in paragraph 2.1.1 the lack of focus of Apeldoorn on circularity in politics resulted in the selection of valorisation options focussed on the goals of the department of management and maintenance of public spaces (improving soil quality by processing and applying leaves and pruning) , and on the selection of valorisation options towards biobased initiatives that are supported by Apeldoorn (Experience lab at CODA and Paper industry museum). Currently treatment of bio-waste from Apeldoorn is mainly performed on regional scale.

As described in paragraph 2.2.2 the amount of available bio-waste of public spaces is relatively small and most bio-waste is only available at certain periods of the year. In combination with the goal of Cityloops to focus on processing inside the city rather than working on regional scale, the focus was on valorisation processes that can be performed on small scale, or processes on large scale that can shift between different raw materials (bio-waste sources) throughout the year.

As the selection process was used to select valorisation options to be demonstrated inside Cityloops, only processes with a TRL of at least 4 were considered. The availability of knowledge and experimental facilities of Wageningen Research towards extraction of fibres from bio-waste was also considered.

3.2. Long list of evaluated valorisation options in Apeldoorn

The valorisation options for bio-waste and biomass in general are manifold. A categorisation based on the type of process was used to show the examples. Abbreviations used for the different bio-waste streams considered are: Pruning (Pr), Leaves (L), Grass (G), Japanese Knotweed (JK), and All (A)

Handicraft

Valorisation option	*Bio-waste*	*Policy*	*Circularity*	*Bio-waste parameters*	*Processing Parameters*
Carpentry	Pr	+	+	+	-
Flower bouquets	G/JK	+	-	+	-
Confetti	L	+	+	+	-
Christmas decorations	A	+	-	+	-
Art objects	A	+	+	+	-

Biochemical/Agricultural

Valorisation option	*Bio-waste*	*Policy*	*Circularity*	*Bio-waste parameters*	*Processing Parameters*
Landscaping	Pr	+	+	+	-
Composting	A	+	+	+	+
Bokashi	L	+	+	+	+
Use in insulation	A	+	-	+-	-
Production of PHA	A	-	+	+-	-
Fermentation towards Food/Beer	A	-	+	-	+
Substrate for Feed /Black soldier fly	G	+	+	-	+
Feed for chickens	G	+	+	-	+
Substrate for Funghi production	G	+	+	-	-
Fermentation towards chemicals	A	-	+/-	+-	-
Biogas production	A	-	+	+	+
Biofuel production	A	-	+	+	+
Fermentation towards ethanol	A	-	+	+-	+-

Mechanical

Valorisation option	*Bio-waste*	*Policy*	*Circularity*	*Bio-waste parameters*	*Processing Parameters*
Building materials: particle board	Pr	-	-	+	-
Building materials: Hempcrete	Pr	-	+	+	-
Building materials: Binderless board	A	-	+	+	-
Building materials: Mycellium composites	A	+	+	+	+
Cellulosic fibres/paper	A	+	+	+	+-
Packaging material	G	+	+	+	+-
Substrate for soil improvement	Pr	+	+	+-	+
Catlitter	Pr/G	+	-	+	+-
Filler for concrete	A	-	-	+	+
Fuel pellets	A	-	-	+	+-
Absorber for chemical spills	Pr/G	+	-	+	+
Filler/Fibre for 3D filament	A	+	+	+	+
Filler/Fibre for injection moulding	A	+	+	+	+

Thermomechanical

Valorisation option	*Bio-waste*	*Policy*	*Circularity*	*Bio-waste parameters*	*Processing Parameters*
Biochar production	Pr	+-	+	+-	+-
Biocrude (oil) production	Pr	+	-	+-	-
Activated coal	Pr	+	+	+-	-

Chemical

Valorisation option	*Bio-waste*	*Policy*	*Circularity*	*Bio-waste parameters*	*Processing Parameters*
Syngas production	A	-	+	+/-	-
Chemical production	A	-	+	+/-	-
Bioethanol production	A	-	+	+/-	-
Phenolics production	A	-	+	+/-	-
Cellulose production for paper	A	-	+	+/-	-
Cellulose production for textiles	A	-	+	+/-	-

CityLoops is an EU-funded project focusing on construction and demolition waste (CDW), including soil, and organic waste (OW), where seven European cities are piloting solutions to be more circular.

Høje-Taastrup and Roskilde (Denmark), Mikkeli (Finland), Apeldoorn (the Netherlands), Bodø (Norway), Porto (Portugal) and Seville (Spain) are the seven cities implementing a series of demonstration actions on CDW and soil, and OW, and developing and testing over 30 new tools and processes.

Alongside these, a sector-wide circularity assessment and an urban circularity assessment are to be carried out in each of the cities. The former, to optimise the demonstration activities, whereas the latter to enable cities to effectively integrate circularity into planning and decision making. Another two key aspects of CityLoops are stakeholder engagement and circular procurement.

CityLoops started in October 2019 and will run until September 2023.

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