

Circular Economy Action Plan

Chemelot Circular Hub's
Transition Agenda



Leading Circularity

Colophon:

This document has been compiled based on the input of many. This process has been overseen by Chemelot Circular Hub's Program Office. Michiel Stork, as team member of CCH's Program Office, has coordinated the process, with support from others in CCH's program office (Paul Brandts, Ardi Dortmans, Jelle Egas, Eef Middendorp, Maurice Olivers, Maud Simons, René Verhoeven and Servi Verstappen).

This CEAP is intended to inform and inspire the journey ahead and has been written in the action modus, however:

- For many of the intentions expressed the business case is not (yet) acceptable and the investment decision hasn't been taken; funding (government support) is thus needed to create an acceptable business case.
- Targets and ambitions mentioned in this document should be interpreted as inspirational targets/ambitions, and are not formalized targets/ambitions of the CCH partners mentioned.
- The projects mentioned in this document often contribute to meeting these inspirational targets, but often many more actions need to be taken before these targets would be delivered.

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April 2021

Dear reader,

With the Chemelot Circular Hub (CCH) initiative in the south of Limburg, a broad alliance of parties has embarked on an exciting and necessary journey. An expedition to look for a sustainable and circular way of living together. We, the public and private partners, brought together in Chemelot Circular Hub's regional board, are proud to present our Circular Economy Action Plan (CEAP) that will support our voyage of discovery.

Elaborated by the unique multi-helix partnership between companies, knowledge institutes, governments and residents in and around Limburg. Together we have condensed our dreams, ambitions and plans into this concrete, varied and integrated action plan. Not only do we have a display of our actions, but in the process of compiling we have established new mutual relationships, discovered new common interests, and we have grown in the collective image of our circular future.

This CEAP was established with the contributions of many enthusiastic colleagues in many different organizations. Thanks to all for these contributions! With this CEAP all parties are confidently entering a new phase of the transition to a circular economy. It is a living document, built on an integrated approach based on four pillars that support our development and growth ambitions, provides detailed information about the chosen paths to circularity, especially focusing on the underlying projects and connections between the various pillars. The CCH parties invite you to join us, making our plans reality, to set out on our joint expedition reaching to that one summit: becoming truly that Chemelot Circular Hub. New partnerships are necessary in order to achieve these plans, to demonstrate our solutions and tell our story. Are you, like us, willing and able?Let's do this!

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Proud partners of Chemelot Circular Hub



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¹ Inclusion in this list doesn't imply approval of all targets and projects mentioned in this CEAP.



We are taking
the lead



For a circular
future

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1

Join the
journey of
discovery

Vision and ambition

The world is looking for a way of living together in which we are in balance with our planet and guarantee a sustainable future for next generations. A broad alliance of parties around the Dutch chemistry and materials cluster Chemelot is now developing a world that is free from waste and in which used products and materials are processed into new raw materials for new products. Clean, safe and sustainably competitive. Using innovative chemistry as a growth accelerator for the transformation to a sustainable economic and socially prosperous future.

The Netherlands are facing enormous challenges. How can the nation emerge stronger from the corona crisis, while at the same time making the world more sustainable, ensuring everyone can participate and help make and keep us all healthier? There is also a growing awareness in the Limburg region of how urgent it is to look ahead together, and to proactively make the economy stronger. This is why Chemelot Circular Hub's common goal is to meet the social and economic challenges we face head on, with ambitious circularity targets and deep greenhouse gas emission reduction targets. The joint parties must act now and plot out the path to a circular future and grasp its opportunities. Chemelot Circular Hub can and is doing this; after all, it is not without reason that its motto is 'leading circularity'.

Broad alliance

Chemelot Circular Hub is the key to solving the urgent and major transitions that the region, as the Netherlands and Europe are facing. The Chemelot Circular Hub consists of a broad alliance of companies, many of the organizations based at Chemelot and Brightlands Chemelot Campus are global leaders in their specific field. Together with knowledge and educational institutes and government bodies they all advocate an integrated, future-proof investment in its core quality: making chemistry, materials, the economy and society circular. With complete industrial-urban symbiosis, with closed material-, energy- and water-loops. Its vision is based on the specific assets in the region, earlier experience with big transformation (from mining to a chemical hub), and now towards a global frontrunner in chemical- and material-science as driver for a circular economy.

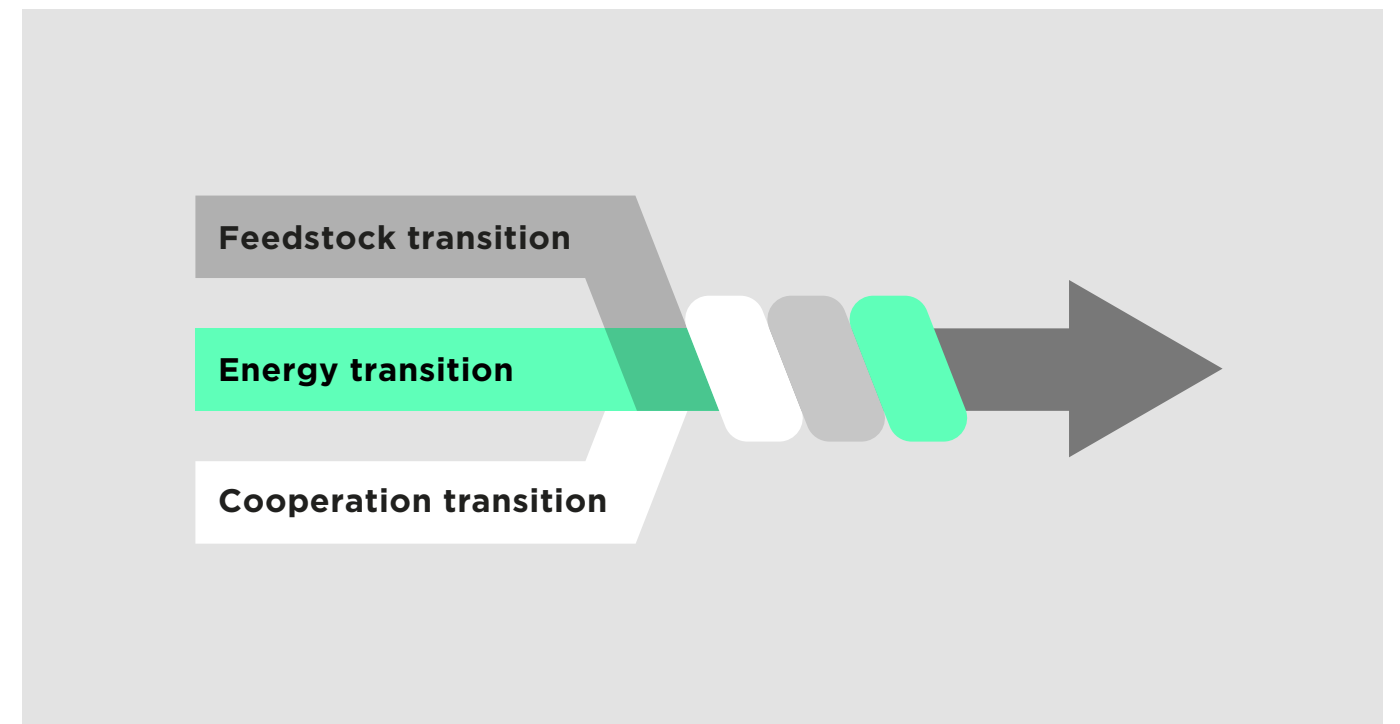


Figure 1: Three intertwined, mutually dependent transitions.

Consumer needs

This ambition further enhances the already large contribution the chemical industry makes to the regional economy, with many world leaders in materials product-market combinations at Chemelot and offers the opportunity to diversify the business models of the chemical industry. It is a direct response to the needs of consumers and residents, the market and last but not least society to avert the risks imposed by climate change and to consequently recreate the current base of our prosperity and wellbeing.

Important intersection

Limburg is positioning itself as an international hub for circular economy and society. It is undergoing a radical innovative transition process, making it all the more urgent to get started now with an action agenda to mobilize strength. This means an agenda that builds on both willpower and resilience to meet the

challenges ahead, to respond flexibly to opportunities and developments that arise in the future. The parties gathered within the Chemelot Circular Hub alliance are at an important intersection that will determine the future. A change in the course of actions is needed. Over the next thirty years, we here at the Chemelot Circular Hub will be cashing in on the opportunity to bend the effects of industrialization in a sustainable direction. Chemistry becomes more and more part of a more consumer driven circular economy and value chains. It concerns cohesion with other sectors: with feedstock and energy supply, with waste companies, with heat management in the region, with companies (Large Enterprises and Small and Medium Enterprises) converting chemical products into end-products (design for recycling), with society and end-users (recycle products), with governments at all levels, and with educational institutes and knowledge institutes within the region and cross borders.

Chemelot Circular Hub thus stands before three intertwined, mutually dependent, transitions (Figure 1):

- A **feedstock transition** from linear to circular value chains based on either recycled or renewable materials;
- An **energy transition** towards climate neutral production and products that do not produce greenhouses after their use²;
- A **cooperation transition**, from cooperation based on value chains to cooperation connecting value networks and ecosystems.

Joining forces to accelerate

Chemelot Circular Hub focuses on accelerating and scaling up towards a circular economy by building a powerful collective movement towards circularity. A movement that provides answers to the questions about the intertwined transitions no single party could solve on its own. Answers to complex issues where system breakthroughs and new ways of integral and inclusive cooperation are needed. Where companies, knowledge- and education-institutes and governments within the ecosystem join forces in a multilevel operation – regional, NL, EU, global - supported by the rapidly growing demand on the part of society, consumers and producers for sustainable circular products. Within CCH we are creating circular value chains, circular business models and increasing earning capacity with the chemistry and materials sector as the main driver. An economic crystallization point and driving force for broad prosperity and the development of social welfare for the entire South-Limburg region and its surroundings.

Creating social impact

All parties joining CCH are creating the leverage needed for the transformation to a circular society, one in which every resident can participate. For residents and consumers, this must lead to an even cleaner, safer and healthier living environment. Tackling demographic challenges like the aging population, the low labour participation³, the share of youngsters not participating to education or the jobs market⁴, education and health. Captivating young generations and securing their loyalty with educational programs focused on circularity, appealing career prospects and the connection to a vital labor market. This also applies to people who are interested in retraining to acquire circular knowledge and skills.

New social development opportunities are arising in the area, creating synergy with the Province's spatial development challenges. For entrepreneurs, Small- and Medium-sized enterprises and industry, it generates economic opportunities, and provides knowledge institutes with a top position globally and structural embedding in the region.

Connecting the dots

When it comes to success in circularity, not managing the probable but leading the possible applies. Chemelot is the ideal location in Europe to ensure the transition to circular raw materials will be a success. Industry and science have been innovating together here for 80 years, in a setting that offers plenty of expertise and the room to experiment and scale up. The region also has a complete, collaborative chain of educational and research institutions at its disposal, making it an excellent starting point

for adaptive education with attractive hybrid learning environments, training and retraining of the workforce to hone current skills and develop circular competences. As transitions require new knowledge and new players, expanding the existing connections with other relevant networks via a bottom-up process is required. Connecting 'the dots' with other chemical- and material-clusters in the Netherlands like EnZuid, Rotterdam or Groningen. But also via cross-border in the so-called ARRRA cluster (Antwerp, Rotterdam, Ruhr-Rhein Area) or other European partnerships as Processes4Planet (Spire) and/or regional chemical ecosystems such as Axelera in France, Eyde cluster in Norway, Lombardia in Italy and the Asturias region in Spain.

Staying competitive

The Chemelot Circular Hub partners are feeling the sense of urgency to become more sustainable. Since they operate on a global level, a level playing field is key when it comes to legislation, regulations and environmental and other levies. A focus on this level playing field is necessary in order to remain competitive. Another factor involves the enormous investments this transition can require around 4 billion EURO until 2030 (refer to chapter 3 for more context about this number). When it comes to costs, 'nothing ventured, nothing gained' applies, and circular processes will have to be invented, scaled up and implemented alongside the need to maintain current production processes. Supporting contributions and new ways of working are needed to help bridge this phase and keep competitive conditions intact and to strengthen them.

² For example: Plastic recycling prevents incineration of plastics at the end of their life – which avoids the greenhouse gas emissions associated with their incineration.

³ Draft provincial environmental vision, retrieved from: <https://ris2.ibabs.eu/Reports/ViewListEntry/Limburg/35a71bdc-d892-46be-8c90-eb8e511f3144>

⁴ Double the Dutch average (Draft provincial environmental vision, retrieved from: <https://ris2.ibabs.eu/Reports/ViewListEntry/Limburg/35a71bdc-d892-46be-8c90-eb8e511f3144>)

Chemelot Circular Hub's guiding goals

Delivering the transitions essentially recreates, safeguards and broadens the region's current prosperity and socio-economic base in many different manners; Chemelot Circular Hub aims at delivering six societally coherent goals⁵:



Accelerate the transitions towards a circular and climate-neutral economy and generate concrete environmental returns⁶

- In 2030: 25% reduction of intake of virgin fossil feedstock (1 Mt) / 25% of the hydrogen production without CO₂ emissions, 25% reduction of water intake for industrial processes and 25% reduction of the harmful substances in emissions to the surface water;
- In 2050: Climate neutral, no intake of virgin fossil feedstock (4 Mt) / 100% of the hydrogen production without CO₂ emissions, no water intake for industrial processes and no harmful substances in emissions to the surface water.



Generate economic returns

- Strengthen the foundations of the regional economy: The Human Capital and the embedding of the regional economy in the national economy (e.g. future logistics);
- Create new, competitive, circular revenue models and synergies, expanding from the chemical- and materials-cluster to amongst others the manufacturing industries (VDL), the Digital cluster (Heerlen) and to other cities transitioning;
- Offer opportunities for entrepreneurs, regional Small- and Medium-sized Enterprises, multinationals, suppliers and customers.



Generate societal returns

- Create inspiring, attracting employment, perspectives and places to live and work;
- Design and shape the transitions together with all residents and consumers with collaborative actions so that they truly embrace circularity in consumption;
- Create a cleaner, safer and healthier living environment;
- Promote the region as a Circular Hub to fuel collective pride and invite people to actively participate.



Increase the labour participation

- Provide competent people to staff new, future-proof and attractive jobs;
- Retrain the existing workforce to acquire circular knowledge and skills (lifelong learning);
- Bind young generations and attract talent from other regions with educational programs focused on circularity, appealing career prospects and the connection to a vital labor market;
- Reduce migration of talents to other parts of the Netherlands or abroad to find a suitable job by providing a bright future perspective for the younger generation within the own region.



Strengthen the region's knowledge position

Attract talent, education institutes, innovation centres, the process industry and the manufacturing industry and cultivate vibrant innovative cooperation.



Establish Chemelot Circular Hub in the Euregion as a showcase of European cooperation

A successful transition will not only have an impact within Limburg, but also internationally, such as for the Euregional partners, the ARRA cluster⁷ and beyond.

⁵ Adjusted from the Investment Agenda 2020- 2030, www.chemelotcircularhub.com/en#download

⁶ www.klimaataakkoord.nl/documenten/publicaties/2020/10/22/koplopersprogramma-cluster-chemelot

⁷ Europe's most important chemistry axis that runs from Antwerp and Rotterdam to the Rhine-Ruhr Area.

1.3

An integral assessment via four pillars

The above goals have been arranged into four characteristic pillars as a basis for the new ecosystem. CCH is working on an integrated approach from these four perspectives.

Pillar 1

Circular innovations and applications

How can we improve our ability to innovate and do business so that we can make an indispensable contribution to the transition to a sustainable, circular economy in Limburg, the EuRegion and in the Netherlands and the surrounding countries? What investments in new first-of-a-kind installations are needed? Which new technologies do we aim to attract to the Chemelot Circular Hub?

Pillar 2

Circular Human Capital Agenda

How can we provide people in the region with worthwhile jobs and attract new people to work in the region? How can we strengthen the circular skills in the region to ensure there are sufficiently skilled people to fulfill the Chemelot Circular Hub's long-term growth ambitions?

Pillar 3

Circular fundament

What is needed for the transition of Chemelot related to its external environment to create a Chemelot Circular Hub with European significance? The transition towards circularity requires new logistics and infrastructure and offers new possibilities for industrial-urban symbiosis (for example closure of the materials loop and exchange of residual heat) and a new vision on the use of scarce space.

Pillar 4

Circular society

How can we develop the surrounding cities and region to build a leading circular testing ground with simultaneous improvement of both the physical and social living environment?

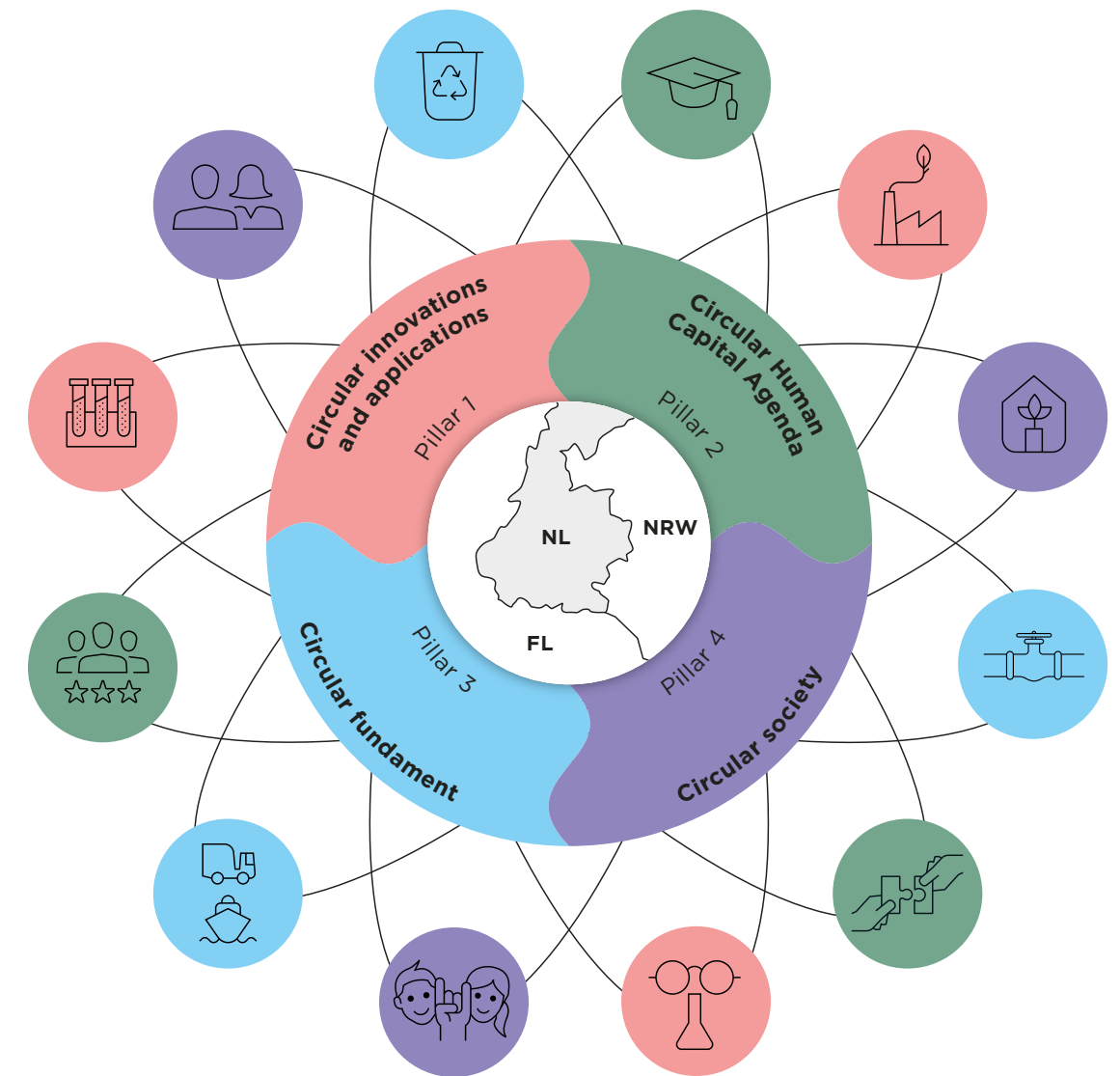


Figure 2: Integrated approach from four perspectives

Delivering these pillars requires major interventions. Chemelot Circular Hub foresees its flagship-approach to be implemented via projects and foremost the transition taking place through synthesis between the different pillar projects into new programs. The different projects listed in the remainder of this Circular Economy Action Plan are being used as 'bricks' to build these innovative transition programs.

Chemelot Circular Hub hopes that this document helps all stakeholders, all people, to see how they can contribute to the circular economy transition.

How do the transitions relate to the goals of policy makers?

The transitions towards circularity and climate neutrality are supported by policy makers on multi levels: The European Union, the ARRRRA-region, the Euregion, the Netherlands, and Limburg region. Chemelot Circular Hub aims at working and partnering on this multilevel approach. Figure 3 shows the key policy aims and instruments to accelerate these transitions.

Figure 3: Visualization of multilevel key policy aims/instruments

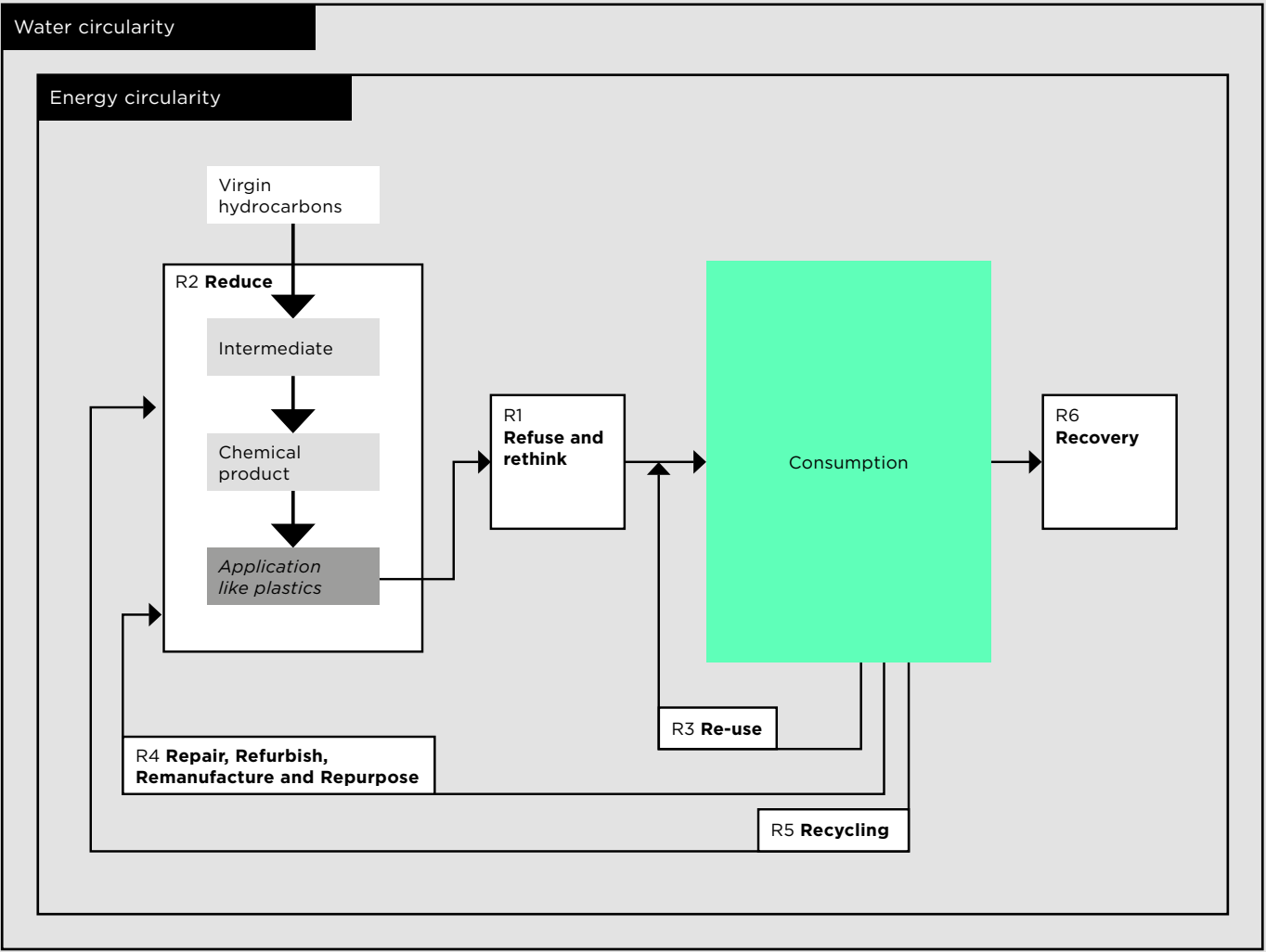
Circularity		
EU EC's Circular Economy Action Plan: <ul style="list-style-type: none">• More sustainable (use of) products• Reduce waste• Increase recycling, specific targets for a.o. plastics and packaging• Update skills agenda	Netherlands Rijksbreed programma Nederland Circulair <ul style="list-style-type: none">• 50% reduction raw material use in 2030• No waste in 2050, fuelled by renewable raw materials Transition Teams "Plastics" and "Manufacturing Industry"	Limburg <ul style="list-style-type: none">• Innovation at Chemelot• Circularity part of Mission-driven economic framework• New Euregional circular value chains• Human Capital Agenda• Actively involve communities• Strengthen role Small- and Medium-sized enterprises

Climate change		
EU Aims at climate neutrality in 2050, recently increased ambition level for 2030: <ul style="list-style-type: none">• Emission trading: Price and cap on total industry + power emissions• Focus on energy efficiency, renewable energy and standards• Climate Pact as cooperation and learning platform	Netherlands 2030 Climate agreement: <ul style="list-style-type: none">• Carbon levy for industry;• Minimum carbon price for power production;• Support for generation of renewable energy and low carbon industry Consequences increased EU ambition to be discussed	Limburg <ul style="list-style-type: none">• Innovation at Chemelot• For buildings: Heat networks/ heat pumps• Generation on-land renewable electricity

What is the Circular Economy?

In a circular economy, consumption becomes more conscious (refuse and rethink) and products can be re-used (by others) or repaired more often. By improving design for recycling and separation and sorting more products can be recycled in loops as short as possible, and the amount of incinerated (recovery of energy) and landfilled waste is limited as much as possible. Meanwhile, the production processes can be optimized to reduce the material-, energy- and water-use.

Figure 4: Illustration of the various circular routes in a Circular Economy⁸



⁸ R-numbers are adjusted from www.rvo.nl/onderwerpen/duurzaam-ondernemen/circulaire-economie/r-ladder, and represent steps on a ladder representing preferred options (from R1 – R6)

What is a Hub for Circularity?

The concept for Hubs for Circularity (H4C) has been introduced in the Processes4Planet’s (former SPIRE) vision⁹, supported by the European Commission. Chemelot Circular Hub is inspired by this concept. H4Cs are self-sustaining economic industrial ecosystems for full-scale Industrial-Urban Symbiosis and Circular Economy. They are closing energy, resource and data loops and bringing together all relevant stakeholders, technologies, infrastructures, tools and instruments necessary for their incubation, implementation, evolution and management. In a H4C the process industry teams up with the regional community, research/academia, the public sector and society, applying disruptive innovation and design to recycle to arrive at new sustainable business models, industries and residents’ involvement.

How will Chemelot Circular Hub operate?

To deliver the required system breakthroughs and manage the interdependencies, the way of working also needs a transition: An alliance of partners has founded Chemelot Circular Hub with the ambition¹⁰ that Limburg will be the first European Circular Hub.

Chemelot Circular Hub takes an integral Multi-helix approach - cooperation between companies, educational and research institutes, governments and consumers. The approach is based on bottom-up, integral and inclusive cooperation. Partners generating the projects and partners choosing whether to participate (see for example Figure 5 for an overview of parties involved in a recent grant application). The approach benefits from connecting different value networks in the value chain, ensuring partners meet each other, cooperation is fostered, and broader and cross borders perspectives are stimulated. This can ensure the comprehensiveness of the transition and keep the many partners together in this challenging journey – with so much to be explored and so many options still open.

⁹ Processes4Planet is the cross-sectoral cooperation on Sustainable Process Industry through Resource and Energy Efficiency: <https://cdn2.hubspot.net/hubfs/2834550/5%202019%20SPIRE%202050%20H4C.pdf>
¹⁰ Adjusted from Limburgs Policy Framework Circular Economy 2.0, retrieved from: <https://ris2.ibabs.eu/Agenda/Details/Limburg/243933b4-e798-4f49-88d8-flb0df6a6e90>.

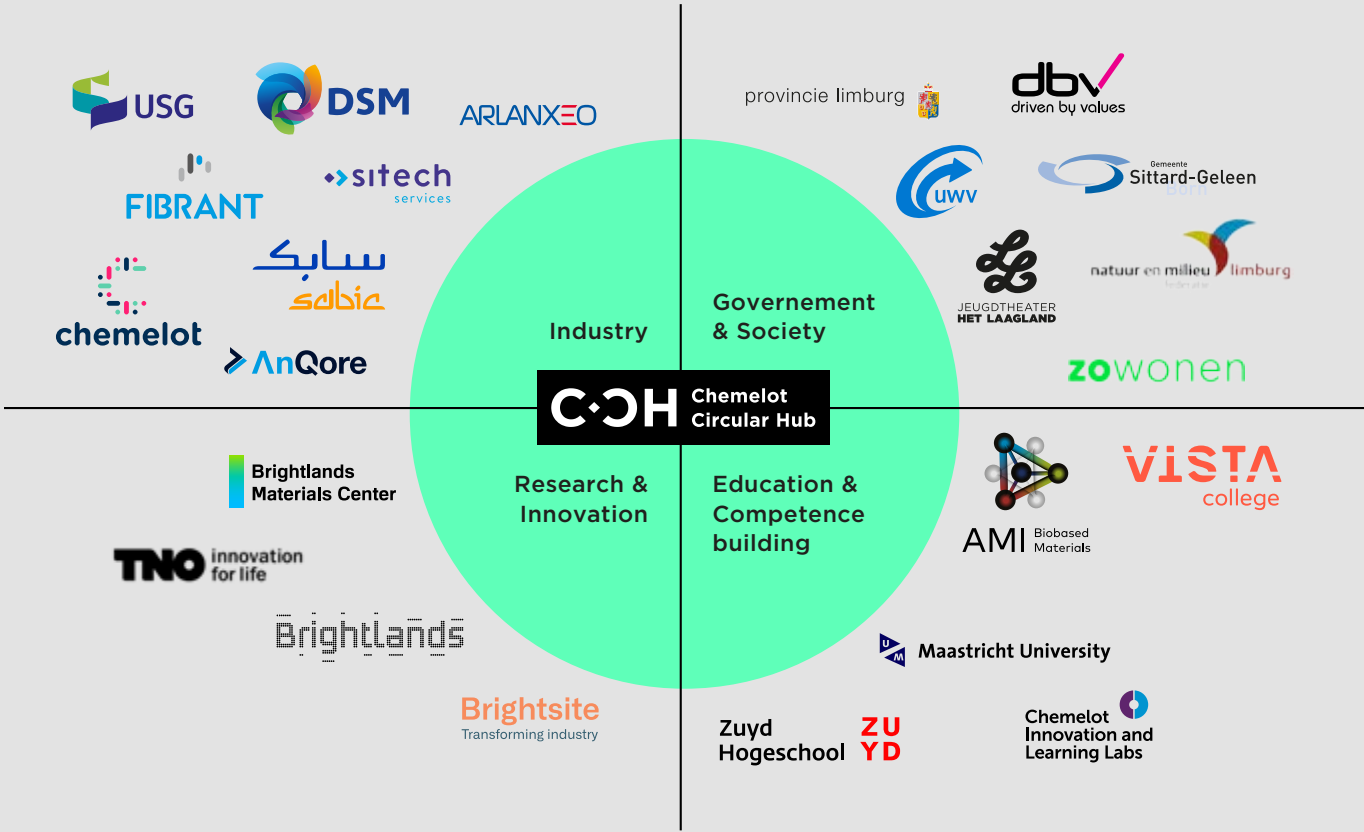
The high variety in partners involved¹¹ lays an as strong as possible support base. To increase the individual and collective success in meeting their needs, these partners cooperate in consortia that represent the envisioned, future value networks.

Chemelot Circular Hub’s partners benefit from their combined executive force described in this Circular Economy Action Plan (CEAP). The determination and success of early movers will accelerate the transitions and over time the full transitions are shaped and materialize: also in other National and European regions of society when other partners join in time.

The success of Chemelot Circular Hub depends on a variety of elements: on people who have the guts, take leadership and entrepreneurship to join the journey and also on the quality of the connections and networks, trust and persistence, consistency, coherency and cooperation.

Chemelot Circular Hub connects and enhances bottom-up cooperation, partners creating consortia, in a complex and dynamic Multi-helix collaboration. Chemelot Circular Hub co-creates on the basis of a ‘coalition of the willing and acting’, maintaining partners’ autonomy, and in close dialogue with an actively engaged and participating society. Chemelot Circular Hub has an open structure, thus new parties can join the coalition of the willing. If you are interested, you are invited to join the Journey!

Figure 5: Parties involved in the recent Euroboros grants application



¹¹ The (international) headquarters of the companies operating at Chemelot, large and small companies at Brightlands Chemelot Campus, companies operating outside Chemelot, Educational and Research institutions, residents in Limburg and the Euregion, their authorities, the Dutch government and the European Commission.

2

Chemelot Circular Hub's journey

Overall picture

Chapter 2 presents all the building blocks that contribute to delivering the Chemelot Circular Hub aims presented in the previous chapter. These building blocks have, based on the Chemelot Circular Hub Investment Agenda¹² and the preceding analytical and strategic work, been prepared bottom-up by 4 teams (in total ~50 stakeholders), representing different pillars, which can deliver the transitions only when components from all 4 pillars materialize, and with an integrated approach:

Pillar 1

Circular innovations and applications

Inventing and using new processes using new materials, described in paragraph 2.2.

Pillar 2

Circular Human Capital Agenda

Reskilling people to enable their success in the circular economy and attract them to the region, described in paragraph 2.3.

Pillar 3

Circular fundament

Arranging the logistics of the circular production processes, and establishing industrial-urban symbiosis, described in paragraph 2.4.

Pillar 4

Circular society

Stimulating circular consumption and involving residents – so crucial for Chemelot Circular Hub's success, described in 2.5.

Chemelot and the wider region strengthen each other in Chemelot Circular Hub:

- Chemelot offers attractive circular jobs and income, while the region provides the skilled labour force for the circular jobs;
- Chemelot boosts entrepreneurship in the region, offering new positions in new value chains (also for SME's), while, amongst others, SME's and Citylabs in the region generate innovative ideas;
- Chemelot offers residual heat, which the region can consume;
- Chemelot offers products that are designed for recycling, while the region lives circularity, including separating waste for recycling (see Figure 4 for all rungs of the R-ladder) generating high quality waste streams to feed the demonstrator plants using of sustainable feedstock;
- Chemelot and the region co-create Chemelot Circular Hub.

Like in any transition, the exact path forward is not (yet) known, but this integral plan offers paths to follow during the journey. Time will tell which paths materialize, and which ones will not. This plan thus needs to be updated regularly. But only with the contribution of all pillars and cooperation between all pillars, can the journey be successful. Chemelot Circular Hub intends to facilitate this integration.

This Circular Economy Action Plan (CEAP) will evolve continuously. In every pillar a multi-helix mix of stakeholders brought his/her circular projects to the table. These projects are the circular 'building blocks'. The synergy and connection between the pillars and these building blocks are the base for the integral Chemelot Circular Hub program. While finalizing this version, already additional multi-pillar activities were being planned. New network connections were developed, synergies being explored. This version is nevertheless communicated now, because this is a continuous process and because the Chemelot Circular Hub community is proud on its plans and would like to give you the opportunity to see how you can cooperate with or participate in Chemelot Circular Hub. This CEAP will be regularly updated.

¹² www.chemelotcircularhub.com/en#download

How to read the many plans described in this chapter?

-

The document is written in the action modus (“Chemelot Circular Hub will...”); for many of the intentions expressed the business case is not (yet) acceptable and the investment decision hasn’t been taken; funding (government support) is thus needed to create an acceptable business case.

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Not all targets mentioned in the document have been approved by those who would need to deliver on them; the targets should thus be interpreted as inspirational targets.

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The projects mentioned in this document often contribute to meeting these inspirational targets, but often many more actions need to be taken before these targets would be delivered.

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This chapter has been prepared bottom-up; starting points are not automatically the same.

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While Chemelot Circular Hub strives towards circularity, not all circles need to or will be closed within the (South-)Limburg region – one of the reasons to aim for a (geographic) expansion of the partners Chemelot Circular Hub is cooperating with.

-

In the next paragraphs, the contribution of each of the flagships to the Broad Prosperity Goals¹³ is described, based on just a quick estimate comparing expected impacts with key Sustainable Development Goals, which have originally been developed by the United Nations (refer to Annex 2). For example:



-

For some pillars – this CEAP is the up-to-date plan describing Chemelot Circular Hub’s plans; for others, this CEAP includes the plans already described in other documents to enable an integral view; in the latter case the other documents are leading.

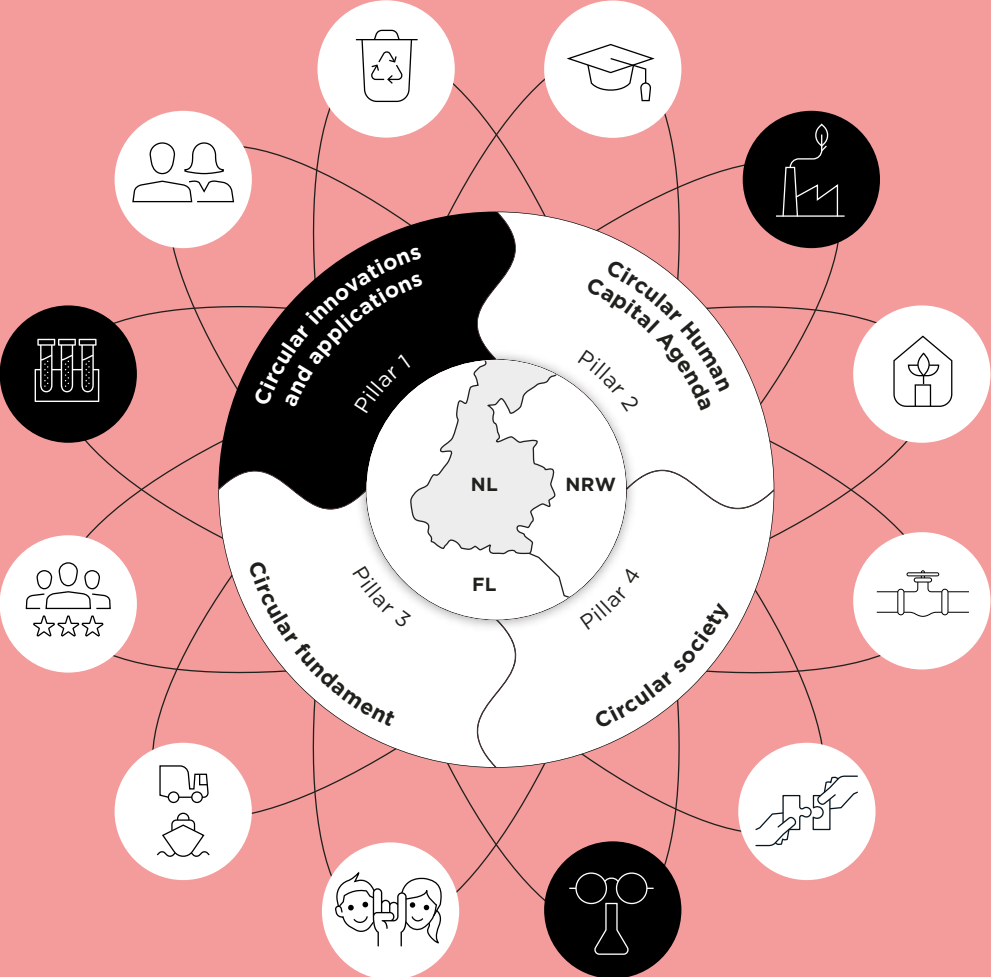
¹³ www.cbs.nl/nl-nl/publicatie/2020/21/monitor-brede-welvaart-de-sustainable-development-goals-2020, chapter 4.3.



2.2

Pillar 1

Circular innovations and applications



Chemelot Industrial Park is already a highly integrated site, with plants using each other's (by)products and with heat integration over the full park. The park emits -1/3 of Limburg's total greenhouse gas emissions¹⁴ (~5,2Mton CO₂e¹⁵), ~3% total Dutch greenhouse gas emissions¹⁶. The greenhouse gas emissions over the full value chain of chemicals produced at Chemelot Industrial Park are significantly higher. Implementing this paragraph's plans with their strong focus on circularity will significantly reduce the greenhouse gas emissions of Chemelot and its products' value chains. The plans close the materials loop (by improving recyclability and increasing recycling, and for water), add biomaterials to the loop, enable processes to be driven by renewable electricity and reduce other emissions – with an integrated approach.

Six flagships have been developed to cover Chemelot Circular Hub's innovation & application needs – real sustainability impact is only made once these are implemented. They are visualized in Figure 6 and described in more detail further below.

These flagships can build on the knowledge available in the many knowledge- and educational institutes present at Chemelot Campus, including the research at low TRL levels¹⁷ - for which the Chemelot Campus is well positioned with Maastricht University and the Aachen Maastricht Institute for Biobased Materials. Further, it is the intention to execute the innovation activities in this CEAP in close cooperation with other networks – Chemelot Circular Hub doesn't need to develop all technologies itself. Chemelot Circular Hub will continuously track initiatives and will periodically update this paragraph of the CEAP.

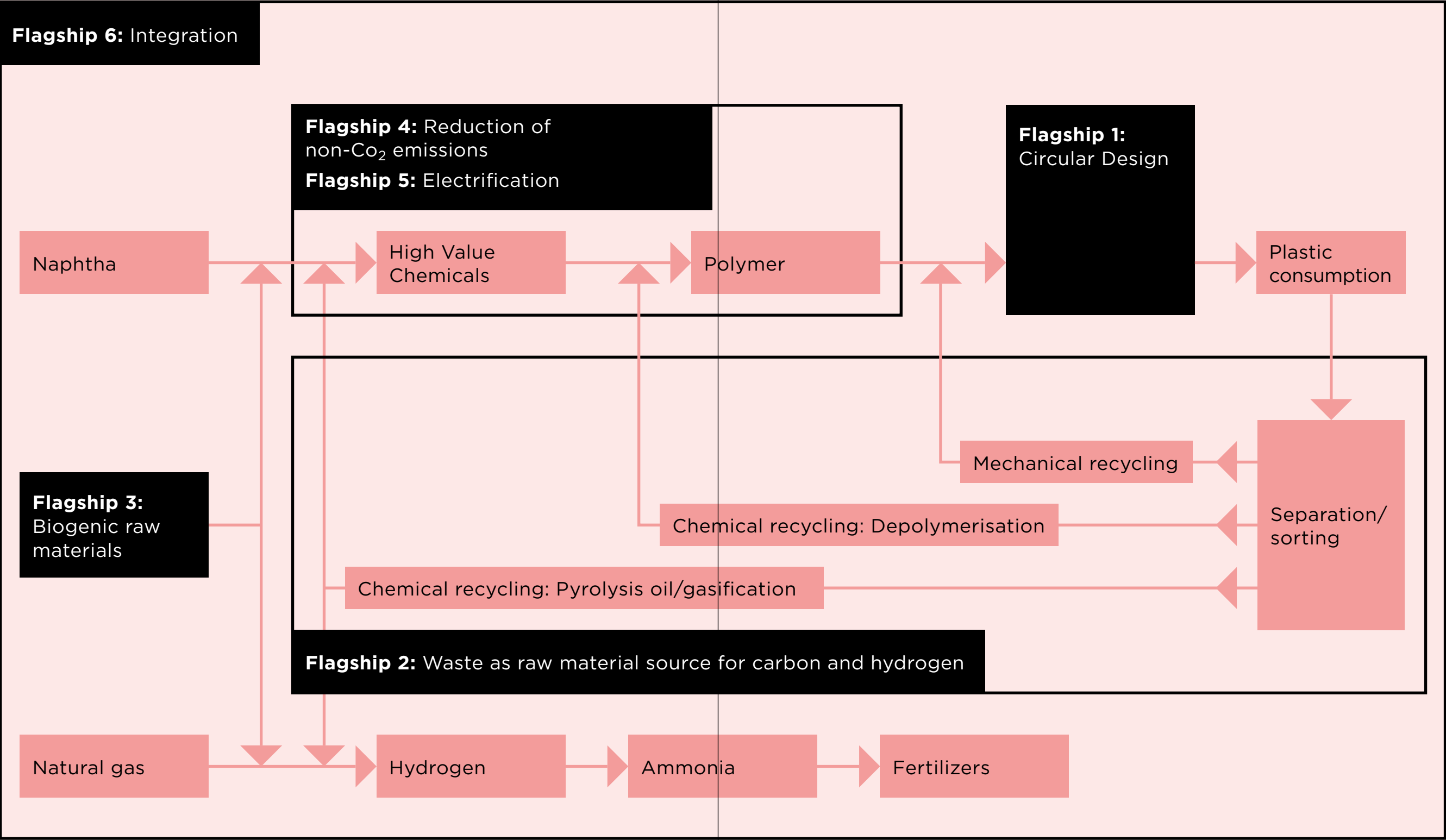
¹⁴ In 2018, the total CO₂ emissions in Limburg were 11,7 Mton and non-CO₂ emissions were 2,8 Mton (klimaatmonitor.databank.nl/Jive?report=co2_rapport_2016&inp_geo=provincie_12).

¹⁵ Emissions for 2019, based on www.chemelot.nl/file/jaarverslag_chemelot_2019.pdf: 4,1 Mton CO₂, 3,7 kton N₂O, corresponding to 1,1 Mton CO₂e, and 370 ton of methane, corresponding to 0,01 Mton CO₂e and 310 ton of other volatile hydrocarbons, using Global Warming Potentials of 298 for N₂O (in line with NEA and EU ETS) and 28 for methane (www.ghgprotocol.org/sites/default/files/ghgp/Global-Warming-Potential-Values%20%28Feb%2016%202016%29_1.pdf) and ignoring the impact of the other volatile hydrocarbons.

¹⁶ Preliminary 2019 greenhouse gas emissions in the Netherlands: 184 Mton CO₂e (www.pbl.nl/sites/default/files/downloads/pbl-2020-klimaat-en-energieverkenning2020-3995.pdf).

¹⁷ Initial ideas, explored at laboratory scale, often at universities.

Figure 6: Visualization of the flagships on innovation and applications



Circular Design



Why

Current products have often not been designed with (full) circularity in mind: the energy use for recycling, or when using the products, is high, or materials are combined that cannot be separated (yet) in the recycling phase. Designing products for recycling will reduce landfilling/incineration, the need for virgin feedstock, energy consumption and greenhouse gas emissions due to closing the carbon cycle. The importance of addressing this need is confirmed in the European Commission's CEAP, stating that up to 80% of products' environmental impacts is determined at the design phase¹⁸, and amongst others in SusChem's Sustainable Plastics Strategy¹⁹, while the importance of "materials" for the energy transition, sustainability and the circular economy is confirmed in the recently published National Agenda Materials²⁰.

What

The goal of this flagship is to make products fully recyclable, or produced from renewable resources, without affecting their overall functionality, with an ambition to enable delivering:

- 50% in 2030
- 75% in 2040
- 90% in 2050

How

Dozens of products and thousands of articles need redesigning, and initially new solutions will not have the scale of economies of incumbent solutions. Therefore a **Center for Circular Design** will be set up where large corporates, SME's and start-ups can rapidly generate circular designs by providing access to relevant knowledge and equipment at limited cost. The cooperation between knowledge centres, educational centres and companies described in Flagship 7 (chapter 2.3) will contribute to the success of this center, enabling students and student teams (compare to Eindhoven Engine) to work on industry projects. The intention is to start in 2022, with 10 companies focused at design active in the center by 2025. In this center, a wide variety of companies designs circular articles, is connected to suppliers and with recycling parties and has access to a laboratory with test-equipment, enabling rapid prototyping and testing. The Center will be housed in an inspiring and open facility called 'Makerspace Circular Products'.

This center will amongst others focus on developing cost-effective²¹ fully recyclable solutions for:

- **All packaging applications** by 2030, as:
 - A significant amount of plastics is used as packaging
 - Currently often many layers of different materials used to provide the required functionality hamper recyclability,
- **Composites** (thermoset and thermoplast), enabling recycling of for example windmills and polyester boats in large volumes, improving recycling technologies (mechanical: improve performance; chemical: improve cost/yield, quality) and doubling the current value of secondary raw materials;
- **Building & Construction** waste: By improving current sorting, separation and cleaning and by cracking strong water-based bonds in bricks and cement, land filling will be reduced, the value of secondary materials can be doubled and recycling will be enabled;
- **Technical plastics** from automotive and electrical & electronics containing a broad spectrum of ingredients like glass fibres, fillers, flame retardants, colorants and stabilizers: The goal is to enable increasing the recycling rate from the ~zero nowadays to 30% in 2030 for the largest plastic streams.
- **Fibers and textiles**, to reduce their (fossil) energy- and water-consumption by increasing recovery of textiles.

The activities can be executed in close cooperation with the City Labs (Flagship 16). The activities in this flagship can be expanded with new applications.

¹⁸ https://eur-lex.europa.eu/resource.html?uri=cellar:9903b325-6388-11ea-b735-01aa75ed71a1.0017.02/DOC_1&format=PDF

¹⁹ www.suschem.org/files/library/Image-Library/Suschem_Sustainable_Plastics_Brochure-FINAL.pdf.

²⁰ <https://materialennl-platform.nl/wp-content/uploads/2020/12/Nationale-Agenda-Materialen-Advancing-Materials-Technologies-1.pdf>.

²¹ Cost-effective under future policy regimes and/or incorporating new business models.

With unified
strength



For the
generations
of tomorrow

Flagship 2

Waste as raw material source for Carbon and Hydrogen



Why

In a fully circular economy, all waste will be recycled towards material sources to be converted into applications of similar quality/value. This avoids landfilling and incineration, with the associated greenhouse gas emissions, and reduces the use of scarce primary materials. Furthermore, mechanical recycling, and to a lesser extent chemical recycling, reduces the energy consumption and associated greenhouse gas emissions of the production of materials. There is large potential for improvement, as for example currently in the Netherlands only ~15% of disposed plastic waste is recycled²². While in principle the collection and sorting of waste can be designed in such a manner that much more waste can be recycled, its costs effectiveness can be improved.

The importance of these developments is, amongst others, stressed in the Dutch roadmap for the chemical industry²³, the Dutch Multiyear Mission Driven Program on Closing Industrial value chains²⁴, and the SusChem Plastic strategy²⁵.

What

Likely, there will be a dynamic portfolio of many technologies, aiming at recycling of plastic waste and biomass-waste. Innovations in the separation, sorting and recycling technologies (both physical recycling, like mechanical recycling or solvolysis, and chemical recycling, like depolymerisation, pyrolysis or gasification) will improve the efficiency and applicability of all technologies, which will impact the relative attractiveness of the pathways. For example, in case mechanical recycling could be applied economically to more waste streams, more energy consuming technologies like gasification or pyrolysis might become less attractive pathways. The aims are to enable that:

- By 2025 key technologies have reached full demonstration stage on industrial scale within the Chemelot Circular Hub perimeter, additional waste streams have been identified and a model describing the preferred routing of waste through the various pathways based on energy, carbon and capital efficiency is operational;
- By 2030 all waste generated within the Chemelot Circular Hub perimeter can be treated in such a way that optimum carbon recovery is achieved and additional sources from elsewhere will be sourced; this contributes to replacing 1 Mta virgin fossil feedstock²⁶.
- By 2040 the cost of all recycled waste-based feedstocks will be at par with fossil sources;
- By 2050 all carbon-containing waste streams can be recycled to secondary raw materials using the pathway with the highest combined carbon and energy efficiency for that particular stream and this contributes to replacing 4 Mta virgin fossil feedstock²⁷.

Figure 7 summarizes the major waste processing routes pursued.

²² www.rijksoverheid.nl/documenten/rapporten/2018/01/15/bijlage-3-transitieagenda-kunststoffen

²³ www.vnci.nl/Content/Files/file/Downloads/VNCI_Routekaart-2050.pdf

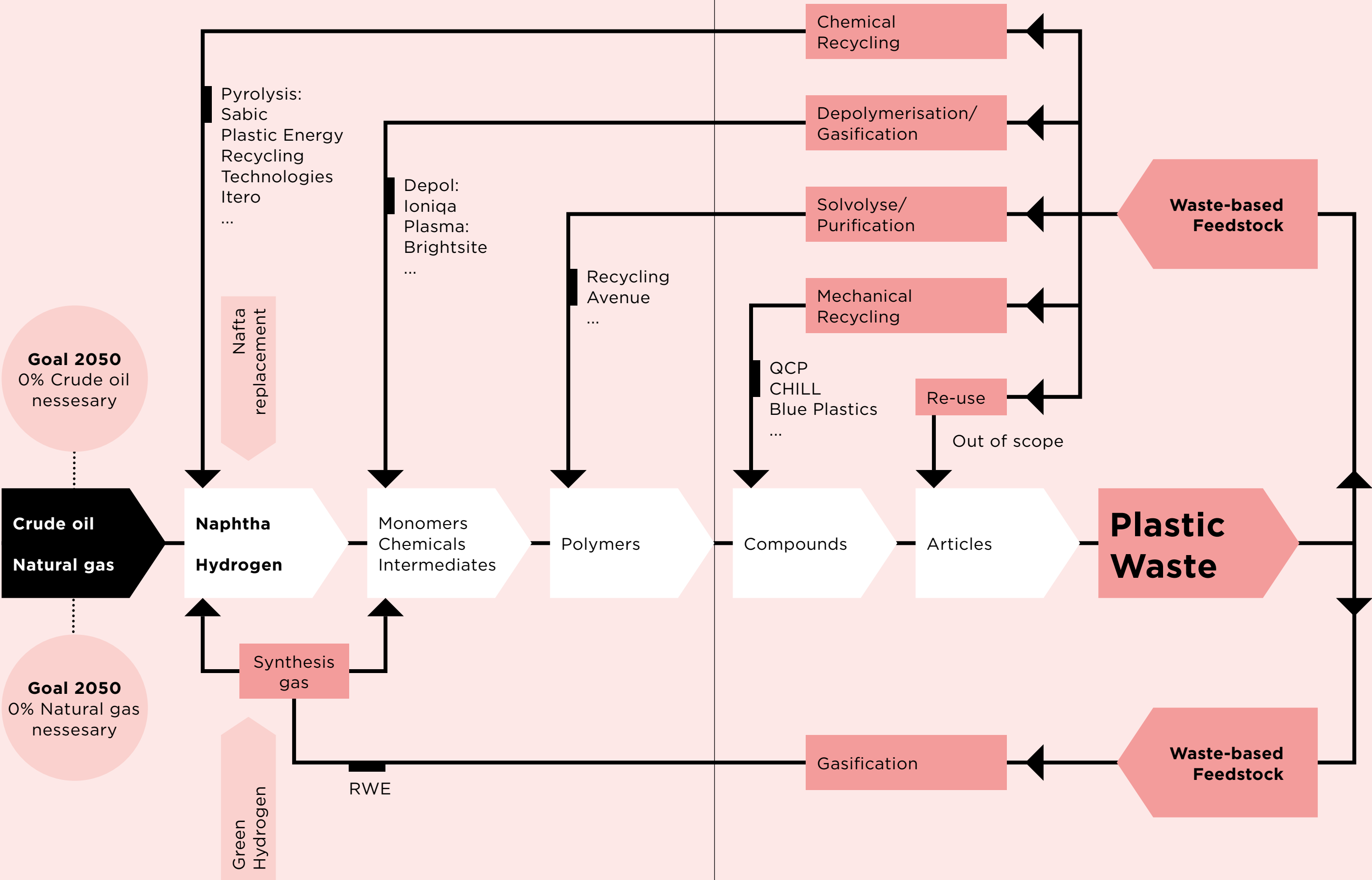
²⁴ www.klimaatakkoord.nl/documenten/publicaties/2019/11/07/mmip6-sluiting-van-industriële-ketens

²⁵ www.suschem.org/files/library/Image-Library/Suschem_Sustainable_Plastics_Brochure-FINAL.pdf

²⁶ www.klimaatakkoord.nl/documenten/publicaties/2020/10/22/koploppersprogramma-cluster-chemelot

²⁷ www.klimaatakkoord.nl/documenten/publicaties/2020/10/22/koploppersprogramma-cluster-chemelot

Figure 7: The variety of waste processing options pursued



How

- Ensuring that the current **availability** of waste streams, their collecting, sorting and utilization and how the waste streams can be **optimally allocated** to the various recycling technology from the perspectives of waste management (no landfilling/incineration), energy-, carbon- and capital efficiency is understood (ensure alignment with the starting points of flagship 14; cooperation with flagship 19). This includes understanding the trade-off between separating and sorting the waste locally (where it becomes available avoiding transport of materials with a low energy density over long distances) and in larger scale installations (potentially enabling more sophisticated processes due to economies of scale).
- Gasification of (in the form of pellets) waste producing **hydrogen** (FUREC: Fuse Reuse Recycle)²⁸, which provides an alternative for the current production at Chemelot based on natural gas (Steam Methane Reforming). Currently, at Chemelot hydrogen is mainly used to produce ammonia, which is subsequently converted into fertilizers, melamine, acrylonitrile and caprolactam, while in the future hydrogen will also be used for the treatment of pyrolysis oil. The technology eliminates the CO₂ emissions from waste incineration in case that is the reference technology but can increase the emissions for the production of hydrogen in case the waste is fossil-based. By 2050 all hydrogen Chemelot consumes should be produced without fossil greenhouse gas emissions (using these technologies, applying steam methane reforming to biogas, by separating off the H₂ produced during steam cracking), when fossil waste would be processed, the technology would need to be combined with Carbon Capture & Storage, or with the production of syngas, which could be converted further into:
 - Methanol - for MBTE production).
 - Fischer Tropsch conversion into hydrocarbons which can **replace 1 Mta virgin naphtha** by 2050. After exploring the economics, a 1 kta plant can be built in 2025, a 20 kta Fischer-Tropsch plant can use part of the syngas produced from waste (see earlier) by 2030, and 100 kta Fischer Tropsch oil can be procured from overseas in 2040.
 - Replacing the cracker feedstock by waste-based feedstock (based on pyrolysis). The current two crackers – Olefins 3 and 4 – convert naphtha to a wide range of chemicals, feeding into the polymer plants, the caprolactam- and the acrylonitrile plant. The goals are:
 - **Pyrolysis** can be used to convert hard-to-recycle waste into valuable cracker feedstocks: Drive innovation for pyrolysis, by demonstrating at least 5 pyrolysis technologies on Chemelot and the crackers using 50 ktpa of pyrolysis oil as feedstock by 2025. This enables:
 - That by 2030 the crackers use 400 ktpa.
 - That by 2040 1 Mtpa pyrolysis oil (or other waste-derived cracker feed is used in the Chemelot crackers).
 - Using all waste streams in the wider region for which pyrolysis is the best recycling pathway as cracker feedstock by 2050.
 - A more efficient process for the **pyrolysis** process will be explored.
 - To attempt finding an even more direct route, **directly converting waste to cracker products** (olefins and aromatics), using an innovative process that finds middle ground between gasification (which breaks waste down to C1-molecules) and pyrolysis (which produces relatively long molecules which are then cracked in crackers). This would eliminate the need to continue to use the existing crackers and generate significant efficiency gains. The aim is to demonstrate the technology at Chemelot by 2025, which enables understanding whether this technology has the potential to replace the pyrolysis route above.

²⁸ www.group.rwe.nl-NL/pers/rwe-generation/2020-11-19-circulaire-waterstofproductie-op-chemelot

- **Solvolysis** to convert plastics like High-Impact PolyStyrene, AcrylonitrileButadiene-Styrene and PolyVinylChloride towards their monomers which should be more efficient than the route through gasification and/or pyrolysis but requires innovation to deal with additives like fillers and pigments. The aim is to demonstrate the technology for at significant waste streams by 2025 and to have a commercial plant in 2030 at Chemelot.
- Recycling of **polyamides** and **polyesters** by depolymerization, with a focus on the two largest products in this group: PA6 and PET, aiming at a demonstration plant producing circular caprolactam at commercial cost and with the lowest (or no) carbon footprint by 2030, while also further increasing PET recycling capacity.
- Furthermore, it will be explored whether/how other waste streams can be recycled as efficiently as possible into hydrocarbons, like:
 - Converting **tyres** into carbon black or new rubbers.
 - Chemically recycling the epoxy and polyester thermoset **composites in windmill blades**, where the high amounts of incorporated other materials such as glass fibres pose a challenge requiring innovation.
- Finally, any remaining CO₂ emissions can be captured and re-used, in applications like gas **fermentation** (converting hydrogen and CO₂ with single cell proteins to useful products like fishmeal) and **Fischer-Tropsch conversion** (combining the CO₂ with H₂ to produce hydrocarbons like synthetic/bio naphtha which can subsequently be cracked in the existing crackers; refer to flagship 3).

To enable and accelerate the testing and scaling up (pilot and demonstration stages) of the various waste technologies, a **field lab with facilities required to test waste processing** (cooperation with flagship 7 and flagship 16) will be set up, with an emphasis on the heavy-duty processes solvolysis and chemical recycling. Innovation of mechanical recycling will also be pursued, in cooperation with CHILL and the regional Small- and Medium-size Enterprises. Furthermore, **waste pre-treatment options** will be pursued.

Flagship 2 is heavily dependent on flagship 14; cooperate with flagship 12.

The activities can be executed in close cooperation with the City Labs (Flagship 16), and with the wider community, entrepreneurs and schools (pillar 2) – jointly collecting materials (like packaging, tires and window frames) for recycling.

Biogenic raw materials



Why

Even in a fully circular economy, some products are not fully collected as recyclable waste (for example rubbers used in tires or detergents) and there will be conversion losses in the recycling process. Even at similar overall demand for chemicals, and even more so in case the demand for chemicals continues to increase, there is thus a need to supplement primary materials to the cycle, which biomass can provide.

The importance of these developments is, amongst others, stressed in the Dutch roadmap for the chemical industry²⁹, the Dutch Multiyear Mission Driven Program on Closing Industrial value chains³⁰, and the SusChem Plastic strategy³¹.

What

Biogenic raw materials are today mostly used to produce only a small share of chemicals, in applications where the structure of the biogenic raw material resembles the structure of the final product, such as natural oils for soap and surfactants, also in cases where bio-based molecules replace different fossil molecules delivering the same functionality. Larger volumes of bio-based chemicals can be produced by mobilizing the biogenic feedstock cost-effectively into a small number of large-volume intermediates. The goal is to develop and (possibly) deploy by 2030 several bio-based routes for the current value chains starting in the crackers; these bio-based materials can feed into the value chain at various places. This contributes to enabling replacing 1 Mta virgin fossil feedstock by 2030 and 4 Mta by 2050³².

Figure 8 summarizes the key biobased processes pursued.

Availability of sustainable biomass

Biomass can be a renewable energy source or renewable feedstock due to its short carbon cycle of 1 to up to 50 years. It is important to ensure that this carbon cycle is as short as possible, and that cultivation and harvesting/resourcing of biomass takes place in a sustainable way. For use as feedstock for the chemical industry, sustainability criteria are still to be developed³³, accounting for (amongst others) the lifecycle greenhouse gas emissions, land use and land use change. Chemelot Circular Hub will be on top of this debate and will pursue increasing the supply of sustainable biomass resources.

How

- A big challenge to be overcome is the dilute nature of the availability of biomass; biomass is spread over large land surfaces, seasonally available, highly variable in composition and often contains much moist. A large research program on **Biomass Mobilization**, preferably in a cooperation within Northwest Europe, will explore the optimal manner to convert biogenic raw material of diverse origin and composition into a broadly usable raw material for large-scale use, with a high-level insight available by end of 2022 and detailed insights available by 2025;
- **Bionaphtha** offers a low carbon route towards the same platform chemicals the crackers at Chemelot currently produce. Different types of biomass can be converted to bionaphtha. A **center of expertise** will be set up to explore the various routes available to produce bionaphtha, and disseminate the knowledge gained.
- Production of hydrogen on the basis of biomass:
 - The gasification process (FUREC: Fuse Reuse Recycle) mentioned in Flagship 2 can also process biomass pellets.
 - A demonstration plant (producing 8 ktpa hydrogen based on biomass that has been innovatively pre-treated by torrefaction to avoid formation of problematic by-products like tar during the gasification) should be operational in 2025 (BrigH2). Refer to Flagship 2 for a description of potential uses for hydrogen.
- Part of the products of a cracker are **benzene, toluene and xylenes** (BTX), for which less (attractive and commercially available) low-carbon routes are available. While currently lignin is burnt to generate renewable energy, a manner to convert **lignin** to oil first, and subsequently to BTX will be explored.
- A new value chain that produces **bio-butadiene**, one of the products from the cracker, from bio-ethanol. The goal is to complete a pilot plant in 2023 and a demonstration plant by 2028.

- An innovative process converting biomass to **levulinic acid** (a C6 chemical which can be converted into amongst others dimethyladipate, which can be converted to polyamide (caprolactam value chain) and to polyurethane). The aim is to have a pilot unit operational in 2024 and a demonstration unit in 2028.
- Finally, commercializing the innovative process to convert sugar to **FDCA**, which can replace PET, will be explored. This would generate a new value chain at Chemelot.

Primary focus for the use of biomass is its conversion to materials; for these residual streams where conversion to materials is complicated, special conversions to energy can also be considered.

Flagship 3 is heavily dependent on flagship 14; cooperate with flagship 12.

²⁹ www.vnci.nl/Content/Files/file/Downloads/VNCI_Routekaart-2050.pdf

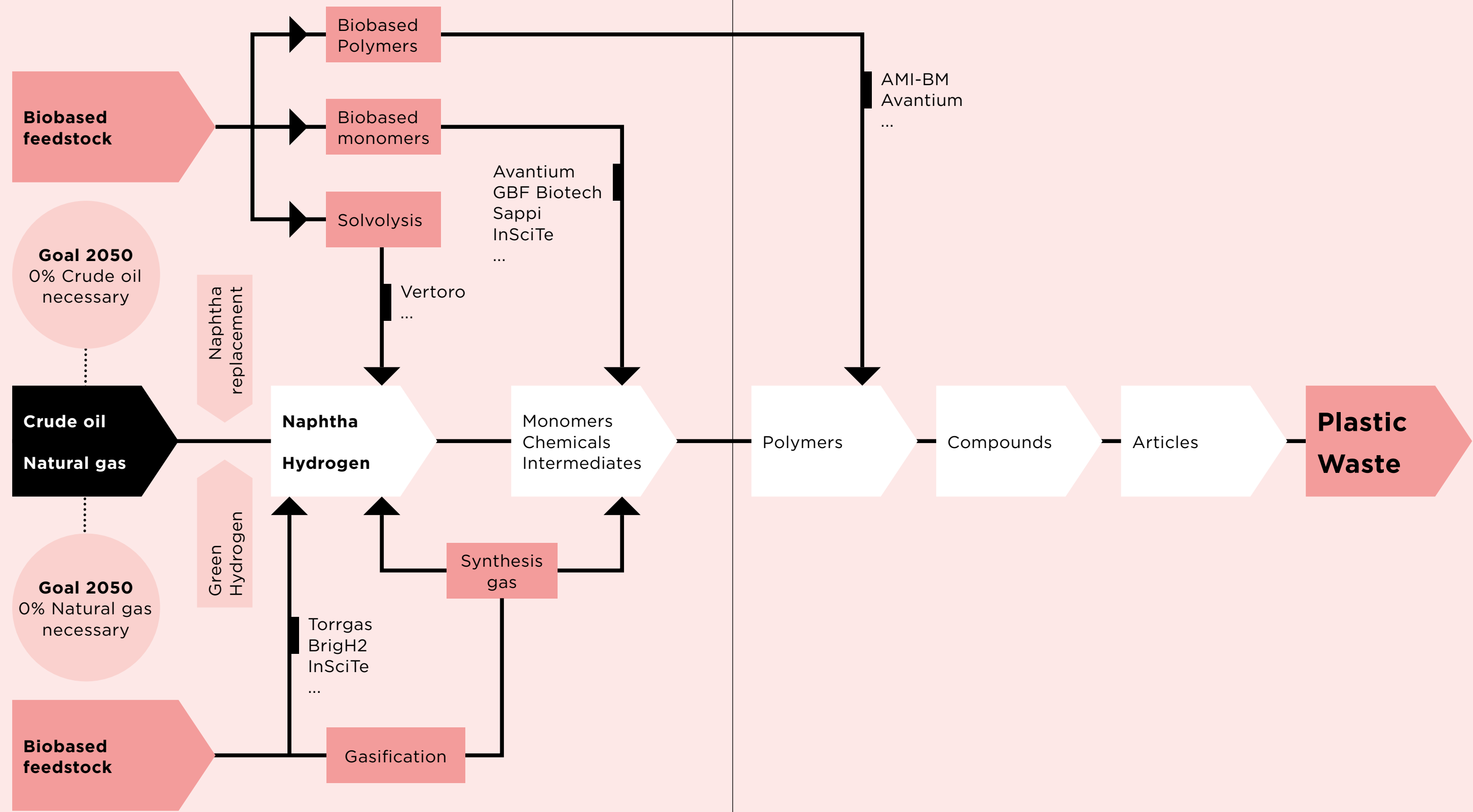
³⁰ www.klimaatakkoord.nl/documenten/publicaties/2019/11/07/mmip6-sluiting-van-industriele-ketens

³¹ www.suschem.org/files/library/Image-Library/Suschem_Sustainable_Plastics_Brochure-FINAL.pdf

³² www.klimaatakkoord.nl/documenten/publicaties/2020/10/22/koploppersprogramma-cluster-chemelot

³³ Which can build on efforts to develop criteria for sustainable biomass for use as energy source.

Figure 8: The variety of bio-based processing options pursued



Reduction of non-CO₂ emissions



Why

Apart from CO₂ emissions, a strategic approach can also be applied to other Chemelot emissions:

- Chemelot's **wastewater** is – after biological treatment - discharged to the river Meuse, without reuse of water or components in the wastewater. The water household at Chemelot needs to be adjusted because:
 - Further downstream the river, the discharged water is used for drinking water and European and Dutch legislation increasingly restrict emissions to surface water
 - Water scarcity will increase and may limit acceptance of intake (and evaporation) of large amounts of water (for cooling).
 - The transition towards a climate neutral and circular site will change processes and related waste streams and thereby affect the water system.

The importance of proper water management is, amongst others, underpinned in Water Europe's Strategic Innovation and Research Agenda.³⁴

- Microplastics** are an increasing risk for the (water) ecosystem. Part of the microplastics present in surface water stems from production and introduction of recycled plastics on the site may increase the issue.
- About 15% of all greenhouse gas emissions from the Chemelot site is emitted as **nitrous oxide** (N₂O) by-product (~1 Mtpa CO₂-e) during production of caprolactam and acrylonitrile.”

³⁴ <https://watereurope.eu/wp-content/uploads/2019/07/Water-Europe-SIRA.pdf>

What

- Chemelot water system:** Optimize the water household and adjust to the needs of the future, circular, processes to reduce emissions of chemical components into the Meuse, use of (cooling) water and water discharge by
 - Increasingly treating wastewater close to the source
 - Recovering secondary materials including nitrogen and scarce metals and heat from water
 - Using alternative water sources (re-using water and rainwater), for the current plants and for newly established (circular) plants.
- Microplastics:** Establish how to quantify microplastic risks (as a consequence of increasing processing of recycled materials) as part of responsible operation and Chemelot's long-term licence-to-operate.

How

- Chemelot water program:
 - Chemelot can take communal wastewater effluent from the cities nearby instead of using water from the Meuse;
 - Organize water governance enabling synergy potential to be further exploited;
 - New technological solutions piloted and implemented;
 - Holistic approach towards water management, combining exploring site transformation scenario's with water management license-to-operate limitations, with innovative technological solutions increasing the solution space and heat optimization of the water household.
- Microplastics/Nitrogen: To be determined.
- Nitrous oxide: Key sources are currently addressed by projects by Fibrant and AnQore.

Electrification



Why

Electrification to drive chemical processes, replacing fossil fuels becomes a key abatement lever with the projected quick switch towards renewable electricity. While currently the cost of electricity is still higher than the cost of natural gas, like-for-like replacement of natural gas by electricity (as in boilers) can become economically attractive when the cost for renewable electricity decreases sufficiently, or policies stimulate the replacement. The importance of these developments is, amongst others, stressed in the Dutch roadmap for the chemical industry³⁵, the Dutch Multiyear Mission Driven Program on Electrification and Radically New Processes³⁶, and Green deal, Processes-4Planet Roadmap and the European's SusChem Strategic Research and Innovation Agenda³⁷.

³⁵ www.vnci.nl/Content/Files/file/Downloads/VNCI_Routekaart-2050.pdf

³⁶ www.klimaataakkoord.nl/documenten/publicaties/2019/11/07/mmip8-elektrificatie-en-radicaal-vernieuwde-processen

³⁷ www.suschem.org/files/library/SIRA-2020/SusChem_SIRA_07_02_V02_interactief.pdf

What

Currently, the share of electricity in Chemelot's energy consumption is only small. The goal is that direct renewable electricity can drive the majority of the processes by 2050. In between goals:

- By 2025 all required electrically driven processes are in pilot stage – or further.
- By 2030 electrically powered processes are demonstrated for all processes currently carried out, or alternatives for those.
- 2040: new factories can exclusively be driven by renewable electricity.

How

With projects to heat on the basis of:

- Electrification of heating** has the potential to replace fossil fuels for many of the chemical processes. The aim is that electric heating alternatives have been demonstrated for all major processes by 2030, of which at least 2 within Chemelot Circular Hub (3 piloted by 2025), in close cooperation with the academic center to be set up in 2021, developing into a leading academic center of excellence by 2025 (linking with pillar 2 (Human Capital Agenda)). More specifically the following technologies will be pursued:
 - Electrically induced plasma**, one of the heating technologies based on electricity, offers the unique ability to achieve very high temperatures. Such high temperatures are required for some of the largest chemical processes currently deployed, such as the conversion of methane (a by-product formed in the crackers which can no longer be used as fuel for their furnaces once they are electrified) into acetylene (for further conversion into ethylene) and for the conversion of difficult-to-treat waste streams. A pilot will be set up in 2023, followed by a demonstration plant in 2025.

- A pilot for the **RotoDynamicReactor** technology that uses electricity instead of fossil fuels to reach the high cracking temperatures needed in the olefins production process.
- Also aiming at the **crackers**, the industrial Cracker of the Future consortium, facilitated by Brightlands, aims to develop electric cracking. The most interesting technologies to pilot will be selected and in 2030 the subsequent demonstration program should be finished.
- Furthermore, it will be demonstrated that heat produced in **steam boilers**, currently fuelled by natural gas, can be electrified, with the ultimate goal that all steam can be generated on the basis of electricity.

Flagship 5 is heavily dependent on flagship 13.

Flagship 6

Integration

Why

With all the new processes to arrive at Chemelot, its energy household will change dramatically. Electricity consumption increases and will be based on intermittent (renewable) supply. This leads to a – continuous – need to optimize and stabilize the energy household.

What

- Develop and apply methodologies to get an overall view on resource/energy streams
- Ensure energy efficiency (for example heat pumps);
- Develop energy storage (electricity, heat);
- Be up-to-speed with the possibilities digitization offers as an enabler of many circular technologies and to stabilize the balance between electricity-supply and -demand;
- Ensure the best intelligence from educational institutes and Small- and Medium-Sized Enterprises is available to jointly innovate;
- Evaluate the impact of proposed changes on the integral footprint of a circular product;
- Develop know-how on the impact of the transition to a circular economy on business models, value chains and society.

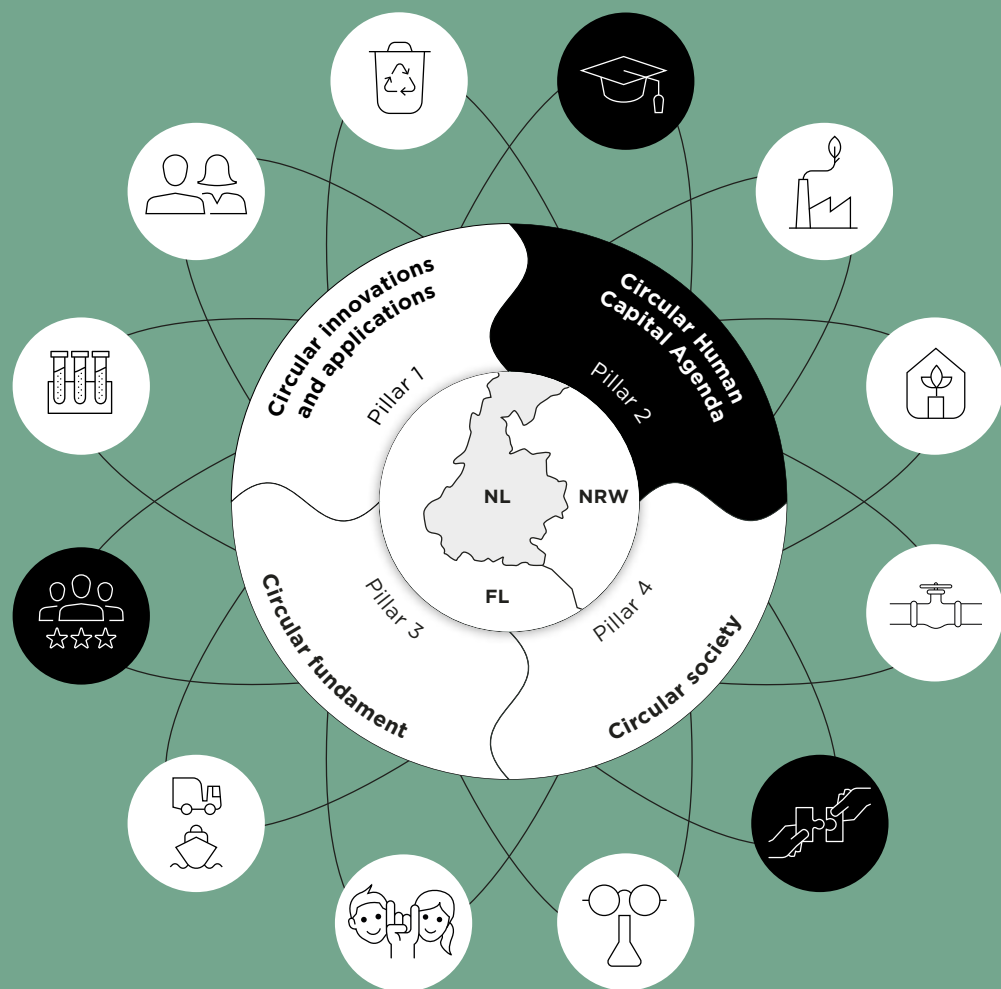
How

- Explore potential of a fully independent (academic?) institute on the assessment of Circular Economy Actions (Netherlands Institute on Circular Economy Assessments):
 - Assessment of integral sustainability assessment and apply this to key actions;
 - Assessment of the impact of the transition to a circular economy on business models, value chains and society.
- Explore developing a model to assess to which extent the actions described lead to zero greenhouse gas emissions and fully circular/renewable feedstocks in 2050;
 - Explore including the impact of purchased chemical intermediates in the assessment;
 - Explore availability, sustainability and applicability of resource streams (energy, waste, biomass, water) in the region (resource stream analysis).
 - Make the broader impact (acceleration of regional economic development, job growth, competitiveness) of Chemelot Circular Hub measurable (to inform, and to communicate – refer to Flagship 21).
- Explore developing a digital twin for key parts of Chemelot Circular Hub, starting small with waste separation;
- Reach out actively and seek for connection between LE and SME's to pursue and implement innovations, mobilizing them to contribute/benefit;
- Communicate the Chemelot Circular Hub innovations (greenhouse gas/circularity) impact to the wider community to establish pride;
- Where necessary, establish more centers of excellence for circular innovations/technologies
- Ensure that new processes coming to Chemelot Circular Hub (and its satellite sites) are communicated and discussed early and proactively in an open dialogue with targeted groups (policy makers, schools) or the wider community (close cooperation with pillars 3 and 4, Flagship 21).

2.3

Pillar 2

Circular human capital agenda



New skills, knowledge and competences are needed to be successful in (the transitions towards) the circular economy, while many more employees will be needed to deliver the plans described in this CEAP. Education and investing in talent are thus key for the success of Chemelot Circular Hub, which is confirmed by Limburg's and European Union's policymakers³⁸.

Many Chemelot Circular Hub partners are already cooperating to deliver innovative education, in Limburg's cities and on Brightlands Chemelot Campus. The existing (and to be expanded) cooperation offers the opportunity to combine inspiring, state-of-the-art or even first-in-the-world educational programs with the innovation and development pursued in Chemelot Circular Hub's knowledge institutes and companies – large and small. Educational programs can contribute to and benefit from the innovation and development programs.

This cooperation can build on an 80-year history of innovating and cooperating, on a wide experience in problem-challenge-based learning at VISTA college, Zuyd Hogeschool, Maastricht University and on a strong collaboration between the these education institutes and the companies at Chemelot in Chemelot Innovation & Learning Labs (CHILL). It delivers on the new way of cooperating described in chapter 1 and ensures the future workforce embraces this new way of cooperating.

³⁸ Limburg's Mission Driven Economic Policy (https://www.limburg.nl/publish/pages/4723/missiegedreven_economisch_beleidskader.pdf) sets three targets on education: Good quality, broad and future-proof education, a resilient and agile workforce through life-long learning and economic attractiveness in a strong ecosystem. The cooperation between the Brightlands campuses and Limburg's educational institutes is strengthened and students and graduates are attracted and maintained for the region with a comprehensive approach. Limburg's Circular Economy policy framework wants to anchor the circular knowledge in cooperation with Limburg's educational- and knowledge-institutes (<https://ris2.ibabs.eu/Agenda/Details/Limburg/243933b4-e798-4f49-88d8-flb0df6a6e90>), The Province of Limburg's draft vision on spatial planning and the environment, which stresses the importance of investing in talent, retaining and attracting talent and the match of the regional labour market with the knowledge- and education infrastructure (<https://www.limburg.nl/onderwerpen/omgeving/omgevingsvisie/terinzagelegging/>), The Regional Innovation Strategy for Limburg, Noord-Brabant and Zeeland for 2021-2027 (<https://www.stimulus.nl/wp-content/uploads/2020/04/RIS3-Zuid-Nederland-2021-2027-21-april-2020.pdf>) confirms the importance of efforts to develop skills and ensure the future employability as boundary condition for the transition; The European's Chemicals Strategy for Sustainability acknowledges the need for "re-skilling and up-skilling the workforce involved in the production and use of chemicals towards the green and digital transition" (<https://ec.europa.eu/environment/pdf/chemicals/2020/10/Strategy.pdf>) and the European Commissions Circular Economy Action Plan (https://eur-lex.europa.eu/resource.html?uri=cellar:9903b325-6388-11ea-b735-01aa75ed71a1.0017.02/DOC_1&format=PDF) launches for a Pact for Skills.

Figure 9: Overview of Chemelot Circular Hub's Human Capital Agenda

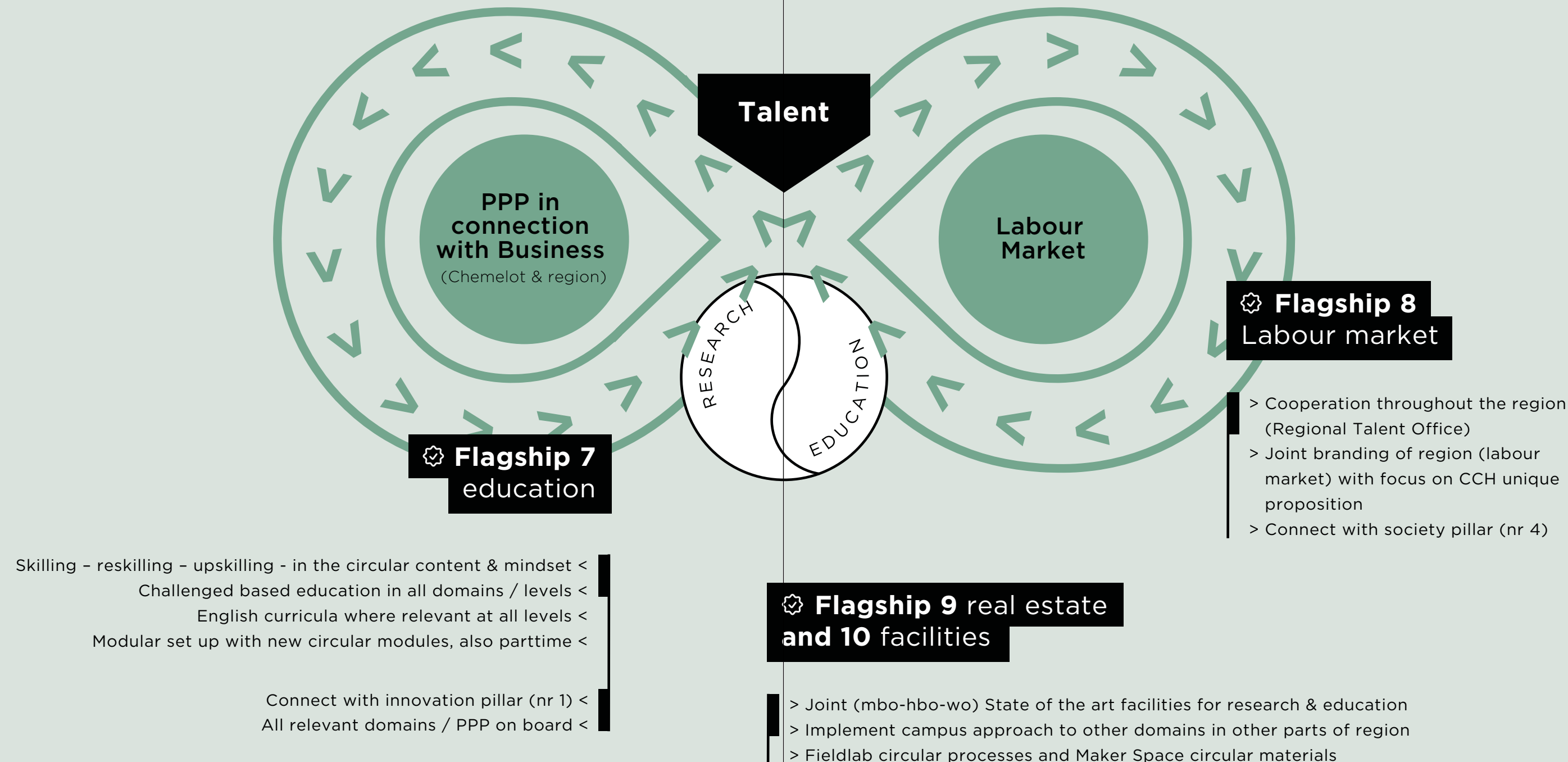
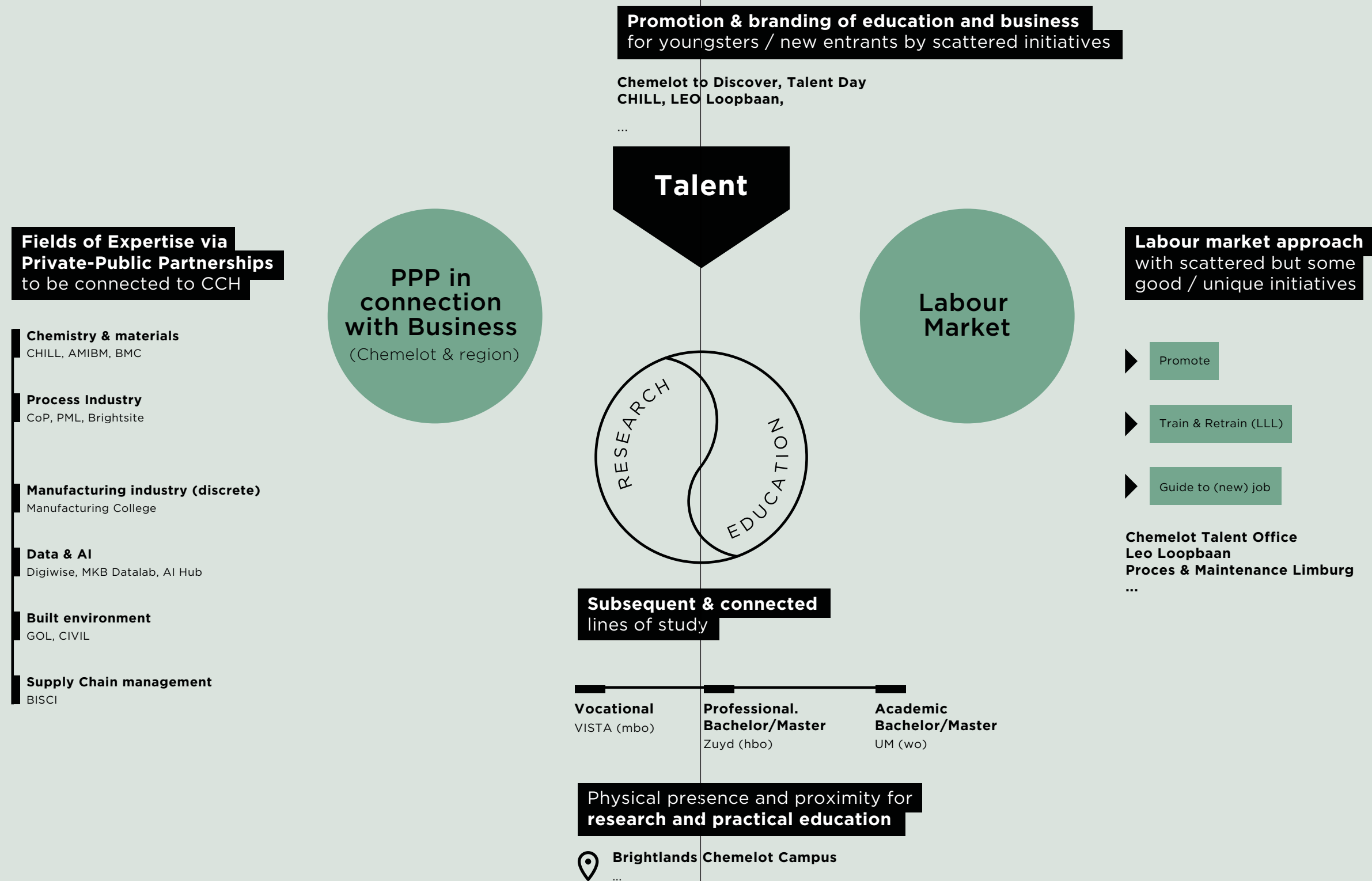


Figure 10: Snapshot of (some of) the parties involved in Flagships 7-10.



As Figure 9 shows, the basis of this pillar is the symbiosis between education and research – essential with the ever-accelerating technological developments: In Chemelot Circular Hub students are trained asking them to work on real projects from the private sector using a challenge-based approach, using public-private partnerships and in close cooperation with many of the activities in pillar 1. This enables us to train the students for the employers' future needs in a practical, real-life setting. Flagship 7 delivers inclusion of the knowledge and skills needed in a circular economy in the educational programs with a modular approach. Flagship 8 attracts young talent and people with experience to Chemelot Circular Hub and helps them with (individual) guidance on the best use of the education modules to pursue a career in the circular economy. In flagship 9 and 10, the real estate and facilities needed for this multi-stakeholder symbiosis are delivered.

Chemelot Circular Hub delivers these flagships in close cooperation with many partners, including many small- and medium-sized enterprises (Figure 10).

The full details of the current and future situation are visualized in Annex 1.

This CEAP describes the current and future state of play and will be kept up to date as the overarching source outlining Chemelot Circular Hub's Human Capital Agenda (HCA). This HCA puts people first; it is about all of us – it could well be about you!

Flagship 7

Strengthening the education chain



Why

Being successful in the transitions requires the workforce, at all levels and in all functions, to understand and contribute to the circular economy. This leads for the existing work force and for new employees starting to work at Chemelot Circular Hub to the need to:

- Gain many new skills, knowledge, and competences.
- Change the attitude and increase their resilience and agility.

As the number of employees working directly or indirectly for Chemelot Circular Hub is expected to increase significantly during the transitions, there is a clear need for tailored and inspirational educational programs for various target groups ensuring attractiveness and efficiency meeting the needs of the employers optimally. These programs thus need to be and are (being) set-up and delivered in close cooperation between educational institutes and the other partners in Chemelot Circular Hub.

Reskilling the existing workforce will enable them to stay and continue to perform while delivering on this program can increase the labour participation, relevant as South Limburg currently has the lowest labor participation of the Netherlands³⁹.

What

Deliver a circular mindset and competence base, symbiotically integrating research and education, throughout the full educational chain, thus providing challenge-based education (education based on real-life problems/projects):

- Continue and strengthen the existing modular approach with subsequent learning lines from MBO, to HBO, to universities with smooth interfaces between the various institutes.
- Continue and strengthen the existing approach where education and research are symbiotically combined.
- **Develop completely new 'circular economy' modules and programs:**
 - At Maastricht University: the world's first accredited Circular Engineering Bachelor program and a new master **Sustainable Manufacturing**.
 - At Zuyd Hogeschool: a new curriculum **Circular Engineering & Science** providing a more circular foundation for all existing technical bachelors starts in 2021 for 600 students starting yearly. This program will be embedded in the practical- and research-spaces of CHILL at Brightlands Chemelot Campus. Furthermore, an Associate Degrees for Operational Engineering, ICT and Business Engineering will be engaged.
 - At VISTA college: change the content of many vocational curricula **to include the changing needs of the circular economy**.

³⁹ Further, 17,5% of the youth in South-Limburg is neither employed nor following an education – twice the Dutch average, draft provincial environmental vision, retrieved from: <https://ris2.ibabs.eu/Reports/ViewListEntry/Limburg/35a71bdc-d892-46be-8c90-eb8e511f3144>

- Increase **the number of modules and programs/curricula offered in English steeply** to enable internationals to follow MBO and HBO education and to allow a smooth changeover to the academic programs.
- Continue to offer **practical training** at Brightlands Chemelot Campus for many additional modules, strengthening the students' links with the Chemelot community.
- Connect businesses, knowledge institutes and educational institutes at Chemelot Circular Hub and set up **maternity rooms** where circular ideas are prepared for implementation:
 - A **sustainable production technology pilot field lab as part of Flagship 2;**
 - A **makerspace sustainable construction materials as part of Flagship 1.**
- Set up a new vocational Industry 4.0 curriculum (covering amongst others de-assembly end-of-life products, sensors);
- A research group 'Circular Supply Chain Management' has been started by (amongst others) Maastricht University and Zuyd Hogeschool.

How

- Maastricht University is the **first in the world offering an accredited Circular Engineering Bachelor**. The accreditation enables a modular approach – allowing to offer those (new) components that match the needs of the ever-developing circular economy. The Bachelor focuses on circular chemical engineering, sustainable biotechnology and engineering physics for Sustainable Manufacturing, combining technical engineering skills with integral thinking (e.g. Life Cycle Analysis), the social dimension and a project management/business training, using Maastricht's challenge-based education approach and international classroom.

- Development of an academic **follow up master** at Maastricht University in **sustainable manufacturing** with focus on circular chemical engineering, reactor engineering and process industry, complementary to the existing biobased materials academic master program.
- Access for internationals is improved by offering more modules in English:
 - Several vocational curricula (laboratory techniques, process technology (operator), engineering (maintenance), product design and ICT) and HBO programs (Applied Sciences, Engineering, HBO-ICT, technical business administration and built environment) continue to be delivered in Dutch, but also in English.
 - New professional HBO masters are planned, only in English, for "Human interaction & data visualization" and for 'Circular Cities and region'.
 - The WO modules continue to be offered in English only.
- Practical training is offered at Brightlands Chemelot Campus for:
 - The Professional Bachelor Applied Sciences, and the Academic Master Biobased Materials (existing).
 - The vocational modules Laboratory techniques, process technology (operator), engineering (maintenance) and product design, the HBO modules engineering, HBO-ICT and technical business administration and the academic bachelors business engineering and the new Circular Engineering, and the Master Sustainable Manufacturing (new)⁴⁰.
- The exact distribution of modules over the various levels is optimized.
- A **maker space** (connected to flagship 1) to jointly develop new circular ideas for circular materials and processes, in which annually 200 students test concepts for 15 SME's using the Communities for Development Concept – operational in 2022 and a **field lab** (connected to flagship 2, an innovative sorting and mechanical recycling facility) (cooperate with flagship 16).

- **Public/private cooperation** between educational institutes and other organizations/business, to align the different educational programs of the different educational levels and set up collaboration with SMEs, thus enabling challenge-based education. Currently this coordination is limited to chemical processes and materials, but this scope will be expanded.
- Streamline the broader cooperation between industry and educational institutes (with **Communities of Practice Limburg** (entangling MBO education with scientific research, students and teachers, and life-long learning with initial education) and company platform Procestechneek and Maintenance Limburg);
- Integrate the cooperation down the value chain towards the manufacturing industry (VDL Nedcar Manufacturing College); stimulate the uptake of ICT – enabler of circularity
 - by education and creation of awareness (Digiwise), SME implementation support (MKB Datalab) and supporting use of artificial intelligence (AI Hub); share insights on sustainability, material use, the energy transition and the need of the end-user in the built environment between to inform the curricula for buildings/infra (Gebouwde Omgeving Limburg) and for installers (CIVIL); and inform the circular logistics curricula in general (BISCI).
- Continue to use the Communities for Development concept in which students test concepts for corporate clients in multidisciplinary and multilevel groups, guided by professionals and coaches;
- Finally, by continuing to employ **hybrid teachers** (working in companies and as teachers as educational organizations) the connection between the educational program and developments in the field is strengthened.

More design-4-recycling activities might be added and there is scope to connect these modules to a Euregional educational approach.

Many of these developments are dependent on their fit in the overall housing strategy of the educational institutes.

⁴⁰ Meanwhile, as Annex 1 suggest, the Maastricht Bachelor Applied Science Program will no longer offer practical education at Brightlands Chemelot Campus due to a lack of space.

Employability and involvement of people



Why

The transitions offer opportunities for young people continuing after graduating from secondary education and for residents from Limburg, the Netherlands and internationals switching careers from other sectors to the technical sector (reskilling & upskilling). With the delivery of flagship 7, Chemelot Circular Hub has an excellent basis to prepare these people for their worthwhile jobs. People however need to know about the opportunities and, as the previous pages, the amount of options can be overwhelming. Thus, people need to discover the opportunities and support to establish the best path for them personally. Building on the existing experience with a labour-market approach, delivery contributes to efficient use of the scarce labour potential, educational programs and to a vibrant labour market in and around Chemelot Circular Hub.

What

Activities will be undertaken using an integral, data-driven approach to build a relation to:

- **Attract people** (also from the wider international Euregion) connect them with the region, and fascinate them with circularity and the circular economy and the involved employers at Chemelot Circular Hub.
- **Help people** to identify their talents/skills, what they like to do, and how they can get there;

- **Support the current workforce** to keep their skills up-to-date and expand to new skills required in the circular economy (like installing heat pumps, operating chemical recycling plants, and digitization (21st century skills)).

Where training needs are identified, a tailor-made selection from the modules described in Flagship 7 will be offered, optimizing the efficiency of offering these modules.

How

Supported by an innovative broad collaboration within the Euregional labour-market, a customer-relations-approach, and the regional City Labs (refer to paragraph 2.5) the following will be done:

- Building on many good initiatives as basis, a program to help the youth to better choose their education and reduce youth unemployment will be set up.
- To attract lateral entrants, a **Talent Office** will connect them with educational organizations and their future employers, organizing events like Talent Day, Chemelot to Discover, Expat center, Chemelot career center (cooperate with flagship 21). On the longer term, the office could also organize activities aimed at circular materials and applications in the built environment, maintenance and at mechanics and in the wider region.
- Once interested people will be offered:
 - An **experience based approach** (for example teaser short films, cooperation with the city labs (see flagship 16), maker space, virtual, Leo Experience & Orientation approach based on awareness on the importance of life-long education and the opportunities the circular economy offers (for the current workforce)) and
 - A broader orientation-funnel on companies, jobs and skills, and stimulating pride on the region (see flagship 21) (for the current workforce and for lateral entrants).

In the future, the activities could be expanded by focussing more on the youth in cooperation with primary and secondary schools, to give content to circular economy jobs and companies using storytelling.

- Coordinate the existing connection with the primary and secondary education system that Technasia, Talent Centraal, STO, Jetnet and PML bring Chemelot-wide.
- A **Talent Office** will be set up, initially focusing on chemical processes and materials at Chemelot, but by 2025 covering the full region and all circular economy topics. This office builds on the existing Leo Loopbaan platform and approach and offers personal advice/guidance/counselling towards **new circular economy jobs** through three routes:
 - Matching people to existing vacancies without a need for further education.
 - Matching people to existing or potential future vacancies with a need for further education as a condition – for which a personal program based on the modules described in Flagship 7 will be compiled.
 - Helping people to identify what they like to do, skills they have and skills that can be developed and the job opportunities to match these, amongst others using the tools described above, after which they can be matched to vacancies.
- Helping the **existing workforce** with a 1:1 approach to select the modules (described under Flagship 7 above) they need to stay well-trained for the (upcoming) circular economy.
- To enable lifelong learning, Zuyd Hogeschool offers many of its programs also parttime, enabling combining learning and working. These programs are offered in Sittard/Chemelot, partially because of the presence of laboratories at Chemelot.

Potentially, in cooperation with pillar 4 (Flagship 21):

- Employees of companies already located on the campus could share experiences, guide internships, deliver guest lectures and propose new people interested in joining – also in case these don't live in Limburg.
- The attractiveness of the cities in South-Limburg as student cities for circularity with international stature can be established and exploited (related to flagship 21).

Real estate for education and research and Setting up labs and professional premises

Many of the activities mentioned above are dependent on a good solution for the real estate. For true symbiosis of education and research, joint housing and facilities are important. These spaces will be coupled to worlds where the practical research takes place, close to or within companies. Teachers can literally guide their students to the research/practical world for which they are educated. Buildings (and the associated equipment) are needed for:

- At Chemelot:
 - A new space⁴¹ for Circular Engineering education at HBO and WO – forming the heart of the circular community, aimed at practical education, including a chemical synthesis laboratory⁴².
 - Continued and expanded use of the current educational space and workspace for students and teachers Applied Science and Engineering streamlining the current two-location (Heerlen, Chemelot) situation – this includes finding a solution for the potentially no longer used building in Heerlen.
 - A circular scale up facility (Fieldlab, see also flagship 2) for mechanical recycling and a Makerspace for design to recycling (see also flagship 1)⁴³.
 - A test location for Circular Materials and applications (expansion of Makerspace, flagship 1) as part of Maastricht's Circular Building Academy potentially, on the longer term).

⁴¹ Potentially (partially) in Sittard-Geleen.

⁴² With MBO continuing its research space for joint (teacher – student) research at all levels.

⁴³ Early 2021 the rented 300 m2 building will become operational, the aim is to increase the space to 1200 m2 by 2030.

- In the cities (Heerlen?), on the longer term: Establishing an “Industry 4.0 – ICT” center for VMBO-MBO-HBO.
- In Maastricht, on the longer term, a Circular Building Academy.

Realizing this plan is conditional on an overall housing plan minimizing vacant buildings (see flagship 9).



Cashing in on opportunities

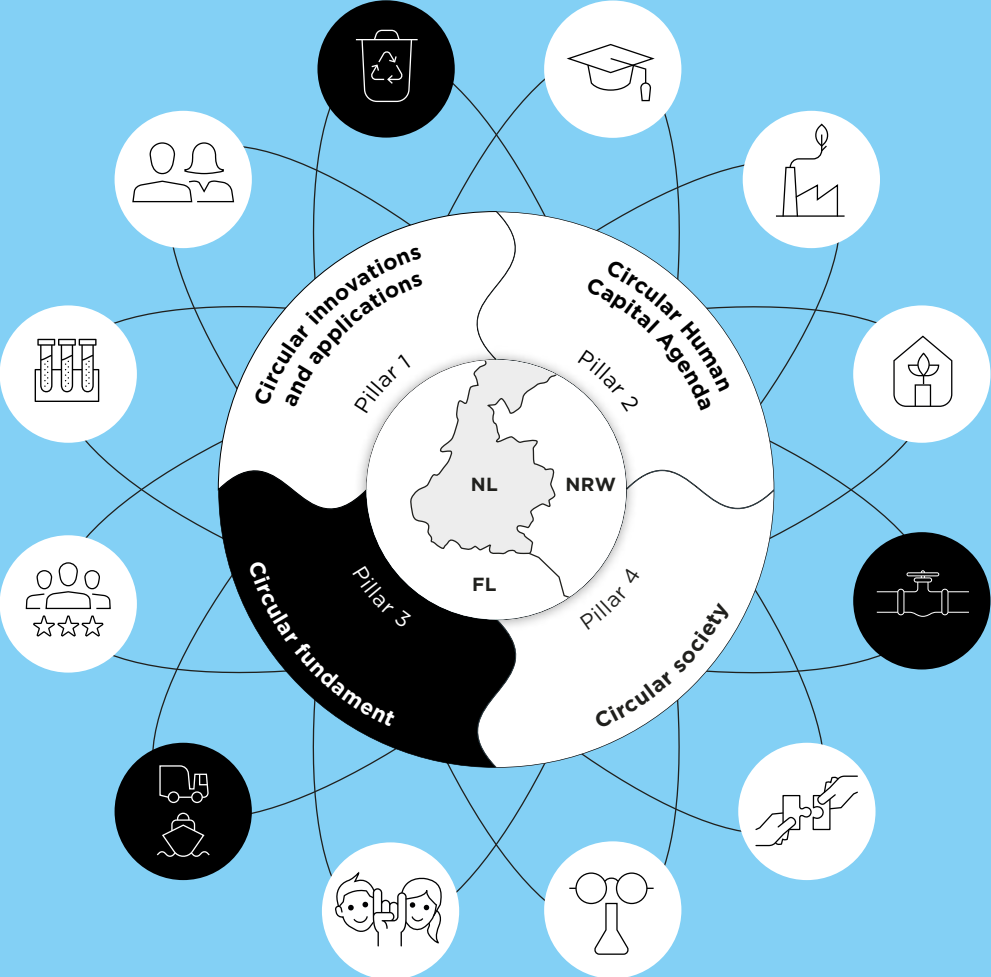


We are the key

2.4

Pillar 3

Circular fundament



Chemelot Circular Hub will profoundly change the production routes and processes at Chemelot. This will have consequences for the (international) energy infrastructure and logistics (optimizing the use of the currently available space at Chemelot, establishing satellite sites and electricity network, pipelines, ship, rail and road) and will impact its surroundings (cooperation with flagship 21), as figure 11 illustrates.

Chemelot Circular Hub can build on earlier thinking, such as the:

- Chemelot Masterplan 2030⁴⁴
- The Chemelot Cluster Energy Strategy⁴⁵, building on its Frontrunner program⁴⁶
- Study Multimodal Corridor (ongoing)
- Study Development plan Stein Harbour (to be started)
- Study Redevelopment areas Chemelot site (to be started)
- Gebiedsverkenning Mobiliteit Westelijke Mijnstreek
- MIRT studie Goederencorridors/Knooppunt 046/Multimodale Agenda Chemelot
- Verkenning circulaire satelliet sites (final)
- Chemelot Vision 2025⁴⁷ and Chemelot Strategy 2050⁴⁸
- Program Circular Water Chemelot (ongoing)
- TIKI report⁴⁹
- Programma Robuust Basisnet Spoor
- Blueports Visie Limburg
- Systeemstudie Limburg⁵⁰
- Study Zero Emission

These sources describe the most up-to-date status of the plans outlined in this paragraph. The summary of the Dutch vision on spatial planning and the environment⁵¹ stresses the urgency of addressing climate change, the energy transition and the circular economy, and proposes a new, integral approach, to balance interests. The Province of Limburg has developed a draft vision on spatial planning and the environment⁵² stressing the importance of Chemelot Industrial Park's transition towards a circular and climate neutral site, the associated spatial and infrastructure needs and that in 2030-2050, Limburg – including Chemelot – depends for the supply of the major part of energy carriers on robust (inter)national energy networks. It stresses the importance of cooperation with local authorities, Chemelot stakeholders, local residents and other stakeholders to develop a supported vision⁵³, and aims at a comprehensive approach for risk- and crisis-communication around Chemelot.

⁴⁴ www.chemelot.nl/visie/masterplan-chemelot

⁴⁵ First version published in April 2021

⁴⁶ www.klimaataakkoord.nl/documenten/publicaties/2020/10/22/koplopersprogramma-cluster-chemelot

⁴⁷ www.chemelot.nl/visie

⁴⁸ www.chemelot.nl/duurzaamheid/chemelot-strategie-2050

⁴⁹ www.rijksoverheid.nl/documenten/rapporten/2020/05/13/adviesrapport-taskforce-infrastructuur-klimaataakkoord-industrie

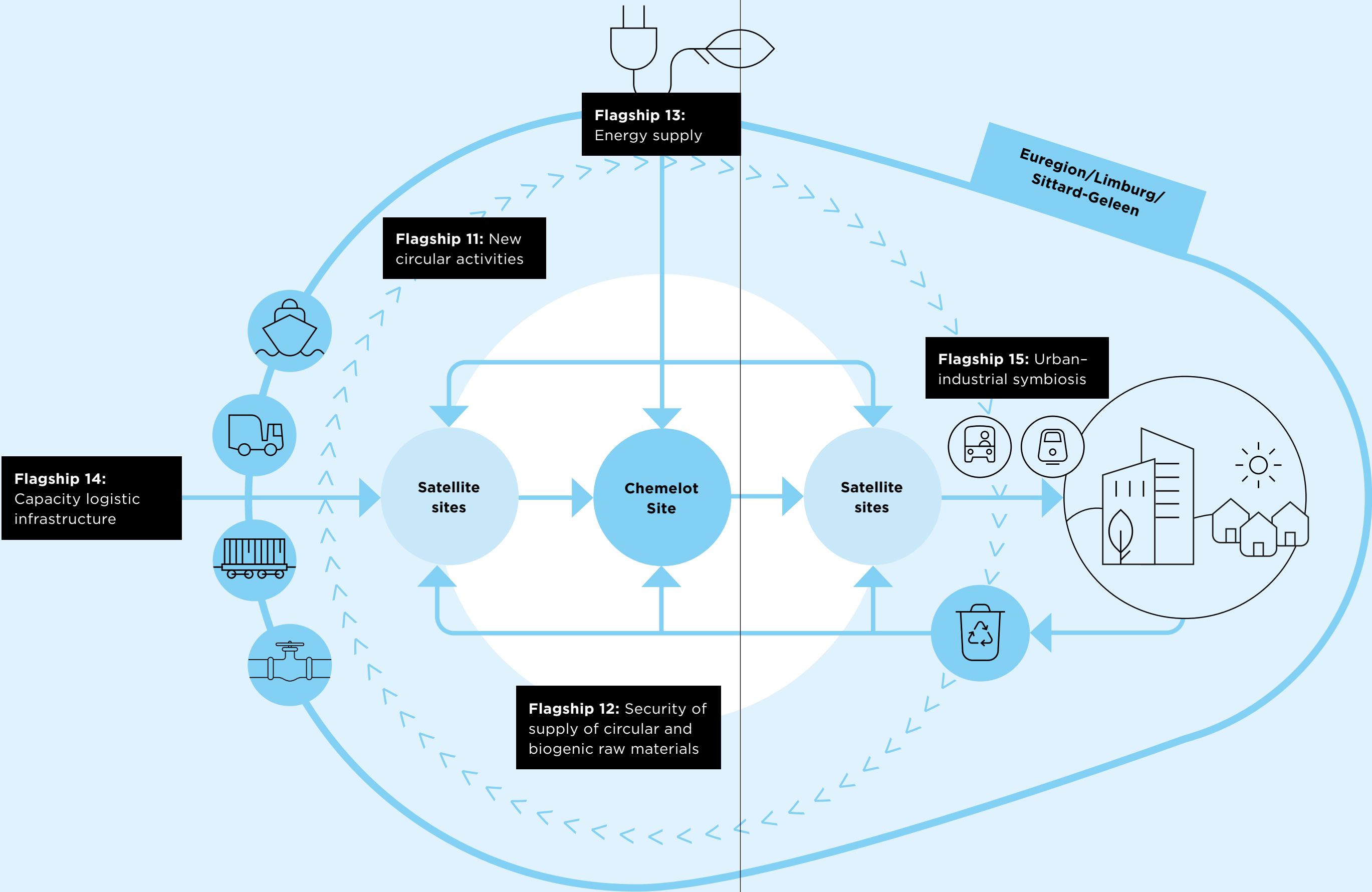
⁵⁰ www.ce.nl/publicaties/2532/systeemstudie-energie-infrastructuur-limburg

⁵¹ www.novistukken.nl/samenvatting/default.aspx

⁵² www.limburg.nl/onderwerpen/omgeving/omgevingsvisie/terinzagelegging/

⁵³ Refer also to Flagship 21.

Figure 11: Overview of the Circular Fundament flagships



Flagship 11

New investments and the establishment of new circular activities



can also be in neighbouring provinces in the Netherlands, Belgium or Germany) to pre-process waste/biomass streams before transporting them to Chemelot. After 2030, this concept will be expanded to Port of Rotterdam and/or Port of Antwerp, to enable sourcing circular and bio-based feedstocks from overseas.

- Activities downstream the value chain will, depending on available space and synergies, be hosted on Chemelot and existing or new business parks/sites nearby (in line with Chemelot's desire to extend the value chains by processing of (bio-based and innovatively recycled) plastics).

Why?

The transition to a circular hub requires new circular activities. To attract these investments, Chemelot Circular Hub needs to offer robust utilities and handling/recycling of waste-water and sufficient physical space.

What?

Physical space is made available at the Chemelot-site for new (circular) investments, with robust utilities and a closed water cycle. To this purpose:

- The limited space currently available at the Chemelot site can be used and the “Drie Kruiken”, “Kampstraat/Ovonde”, “De Maurits/TOP” and “Kerensheide” areas on the site are **redeveloped** to use their (physical and environmental hygienic) space more efficiently.
- New activities are optimally integrated, increasing their energy efficiency.
- Two-three external circular upstream satellite sites⁵⁴ are developed outside the Chemelot site (or existing external sites are expanded;

How?

- In 2030, 2-3 million ton of solids will be pre-processed mostly in (Chemelot) upstream **satellite sites**, operational in the next years (delivering regional recycling). After 2030 and 2050 Port of Rotterdam and Port of Antwerp will also act as 'upstream sites' for Chemelot.
- Downstream activities will, in line with the Masterplan Chemelot 2030, be located at the borders of the Chemelot site, and at satellite sites within around 15 km of the Chemelot site. The feasibility of the various satellite sites will be established as a first step.
- The existing capacity to produce and distribute **utilities** (electricity, demineralized water, steam, sewer capacity) will be expanded.

Citizens' engagement is crucial for the stakeholders' acceptance of these plans (refer to Flagship 21).

Flagship 12

Security of supply of circular and biogenic raw materials



- Setting up a so called Chemelot Renewable Resources Trading Company, to take a strategic position in the waste and biomass market and procure residual streams on behalf of the companies operating at Chemelot; this could deliver synergy benefits and help to get waste streams meeting the specifications for mechanical/chemical recycling. While this idea is currently only in the brainstorm phase, the aim could be to sign the first contract in 2024 and be scaled up by 2030. Currently each company operating at Chemelot procures its own waste raw materials, in the future Chemelot will work together on this important topic.

Why?

With increasing reliance on circular materials, securing access to sufficient circular materials, in time, always, with the right quality and at the right price, is key for the continuity and competitiveness of Chemelot Circular Hub.

What?

Take a more strategic approach towards procurement of waste/biomass streams.

How?

- As a first step, a raw material program Chemelot 2050 will be prepared in 2021/2022, to assess the need (what? How much? When?) for circular raw materials (like household waste, PMD waste, diapers, sewage sludge, organic waste, pig manure and biomass) between now and 2050. Potential to align with Flagship 6.

⁵⁴ The need for satellite sites is included in Limburgs draft vision on spatial planning and the environment, <https://www.limburg.nl/onderwerpen/omgeving/omgevingsvisie/terinzagelegging/>.

Flagship 13

Security of renewable energy supply



Why?

The move towards circular processes will highly increase the demand for electricity (see Flagship 5 in pillar 1). National and regional plans confirm the importance of sufficient availability of affordable and sustainable energy carriers like electricity⁵⁵.

What?

The capacity of the electricity network will be increased (150 kV and 380 kV connections).

How?

Chemelot's needs will be described a.o. in the Chemelot/Limburg Cluster Energy Strategy, which will be updated each 2 years (first publication in April 2021).

⁵⁵ www.limburg.nl/onderwerpen/omgeving/omgevingsvisie/terinzagelegging

Flagship 14

Adequate capacity for logistics infrastructure



Why?

Robust infrastructure with sufficient capacity is crucial for an in-land location as Chemelot Circular Hub and offers the perspective of being a European switch point. Currently, most of the feedstocks and energy carriers (virgin naphtha, natural gas) are supplied by pipeline. 10% of the feedstock and 52% of the products are transported by ship⁵⁶. The energy transition leads to a demand for new transport modalities:

- Circular raw materials are often solids requiring transport modalities like shipping, rail and road transport (cooperate flagships 2 and 19). Ensuring sufficient capacity for the logistical infrastructure from/to Chemelot enables processing of residual/circular materials produced in the region, neighbouring provinces and in the rest of Europe/the world in Chemelot Circular Hub.

⁵⁶ Database Logistiek & Mobiliteit Chemelot, update 2021.

⁵⁷ www.limburg.nl/onderwerpen/omgeving/omgevingsvisie/terinzagelegging/

⁵⁸ Including a pipeline from the harbour in Stein to Chemelot.

- Hydrogen pipelines: Hydrogen is currently mainly used for the production of ammonia and can in the future also be used in several other (new) circular processes, such as hydrogenation of pyrolysis oil and potentially as sustainable energy source too. The most recent insights on the hydrogen needs are described in Chemelot/Limburg's Cluster Energy Strategy.
- CO₂ pipelines or shipping, to transport captured CO₂ towards storage fields (CCS) or potential users (CCU).

Limburg's draft vision on spatial planning and the environment confirms the importance of multimodal infrastructure – including the pipeline Rotterdam-Chemelot-Ruhr-area, and inland shipping⁵⁷.

What?

Develop a future-proof infrastructure, including a focus on added value for the areas surrounding Chemelot:

- To enable the supply of externally sourced **hydrogen**, Chemelot needs to be connected to a hydrogen network. The network can deliver green hydrogen (from electrolysis) or blue hydrogen (on the basis of natural gas, with the associated CO₂ captured and stored), produced elsewhere in the Netherlands or imported to the Netherlands.
- To enable Carbon Capture & Storage at Chemelot, **CO₂ pipelines or CO₂ shipping facilities**⁵⁸ need to be available.
- (Mainly) for **solid feedstocks** the harbour of Stein will be transformed to a sustainable harbour with increased capacity and add a new dedicated multimodal corridor (e.g. for pipelines, electric or hydrogen trucks) between this harbour and the Chemelot site. Furthermore, the rail- and road-connections to Chemelot will be improved.

How?

- **Pipelines:** Three options are explored to transport hydrogen and/or hydrocarbons and/or carbon dioxide: Re-purposing Gasunie’s gas pipelines to transport hydrogen, connection with Rotterdam and connection with Antwerp.
- **Stein harbour:** The scope of the harbour development will be determined more exactly in (pre)feasibility studies first and the aim is to complete the harbour development towards a sustainable harbour (e.g., shore power) by 2025-2030. Measures are taken to reduce noise and increase safety in the harbour and along the corridor. The new dedicated multimodal corridor to the Chemelot site is planned to be ready by 2025-2030, or when possible earlier, turning this corridor into a truly multimodal corridor, and reducing the amount of freight transport over public road, using more sustainable modalities.
- **Rail:** The exact solutions will be established in 2021-2023, followed by feasibility studies. Current thinking is (operational after 2030) to make new connections⁵⁹, to electrify the railway between Sittard – Chemelot (reducing the need to shunt trains on the Sittard station and enabling use of clean locomotives), provide a battery charging station on Chemelot to charge electrical battery locomotives to enable electric rail transport at the Chemelot site and to use hybrid and electrical locomotives towards Chemelot.
- **Road:** Where possible circular raw materials will be supplied by pipelines, ships or rail but road transport will nevertheless increase (Masterplan Chemelot 2030, December 16th, 2019), for which new infrastructure is foreseen⁶⁰.

Citizens’ engagement is crucial for the stakeholders’ acceptance of these plans (refer to Flagship 21).

⁵⁹ Establish a south-bound connection from Chemelot and build a new electrified railway between Antwerp, Roermond (the west branche of the former “IJzeren Rijn”) connecting to the existing lines towards Venlo and Kaldenkirchen (electrified, modernization of the safety system).

⁶⁰ Based on several executed/ongoing studies, the current thinking is to improve the road connections by making a flyover between the Urmonderbaan and the Oude Postbaan, strengthening the crossing between the Urmonderbaan and the Burgemeester Lemmensstraat, connecting the campus with a direct way with the roundabout Nieuwe Postbaan, building a roundabout at Chemelot Gate 7 to improve the connection from Chemelot to the A2 highway, widening the A2 highway and providing truckparking.

Flagship 15

Urban-industrial symbiosis



Why?

A strong physical connection between Chemelot and its surroundings contributes to its attractiveness for people, business, and pilots/demonstration units. The number of residents (and visitors) traveling to the Chemelot site will increase due to the expansion of the Campus (for research and education (refer to flagships 1-8), and the new (circular) activities will also cause further movement of people. In a truly circular hub, the transport of people needs to be sustainable, using road capacity smartly.

What?

Most urban-industrial symbiosis activities are described in other flagships, including:

- Establishing the Chemelot and surrounding area vision with clear added value for the living environment and Chemelot (Flagship 21)
- “Het Groene Net” (Flagship 18)
- Dealing with waste (Flagships 2 and 19)
- The Chemelot water program (Flagship 4)

Here, a remaining activity is described:

- Action plan to reduce travelling (including more working from home) or towards more sustainable travelling between the built environment and Chemelot.

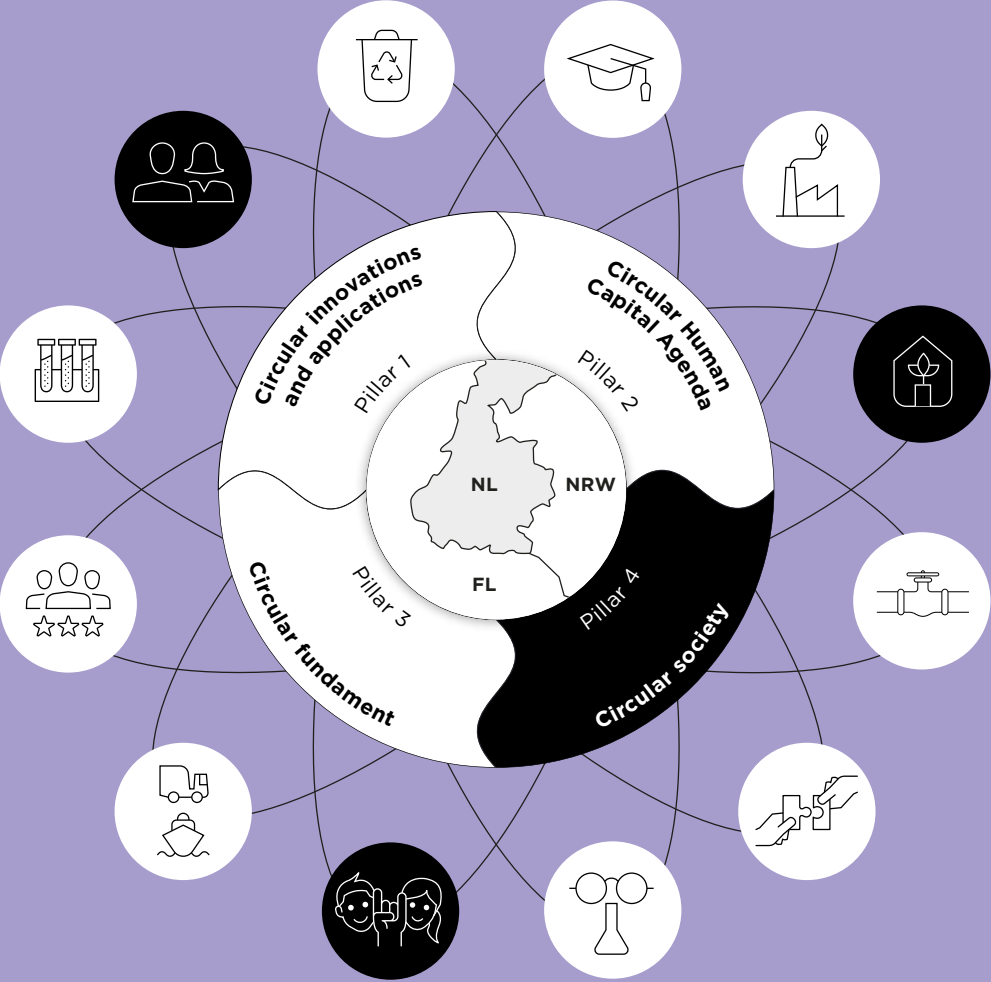
How?

For the transport of persons (operational by 2030):

- Improve **car transport** by providing electric and hydrogen charging points, electrical cars, matching parking capacity to the capacity of the road network. Persons will benefit from infrastructural measures such as a grade separated junction between the Urmonderbaan and the Oude Postbaan and a direct road from Brightlands Chemelot Campus to the A2 highway. Alternative routes for emergency situations will be set up.
- **Bus routes** with direct connection to the Chemelot Campus can be optimized, with a separate bus-lane for express buses Sittard rail station– Chemelot Campus – Maastricht rail station and Randwyck and Chemelot Campus – City Center Geleen
- Express **bike lane** Maastricht – Chemelot Campus

The further “how” is to be shaped, with Small and Medium size- Enterprises, and benefitting from innovation routes.

2.5
Pillar 4
Circular society



The symbiosis between society and Chemelot is based on reciprocity: Society and its citizens strengthen Chemelot, and Chemelot strengthens society (the cities/dwellings and their citizens) (Figure 12). City labs will be used to innovate, educate and communicate, the youth's health will be lifted at primary schools, citizens can benefit from Chemelot's residual heat and cooperating cities will stimulate circular processing of their waste. Chemelot Circular Hub aims to create close cooperation opportunities with the Euregio. Finally, Chemelot Circular Hub aims to increase the regions attractiveness as a place to live, and to strengthen regional pride on the circular steps it is taking.

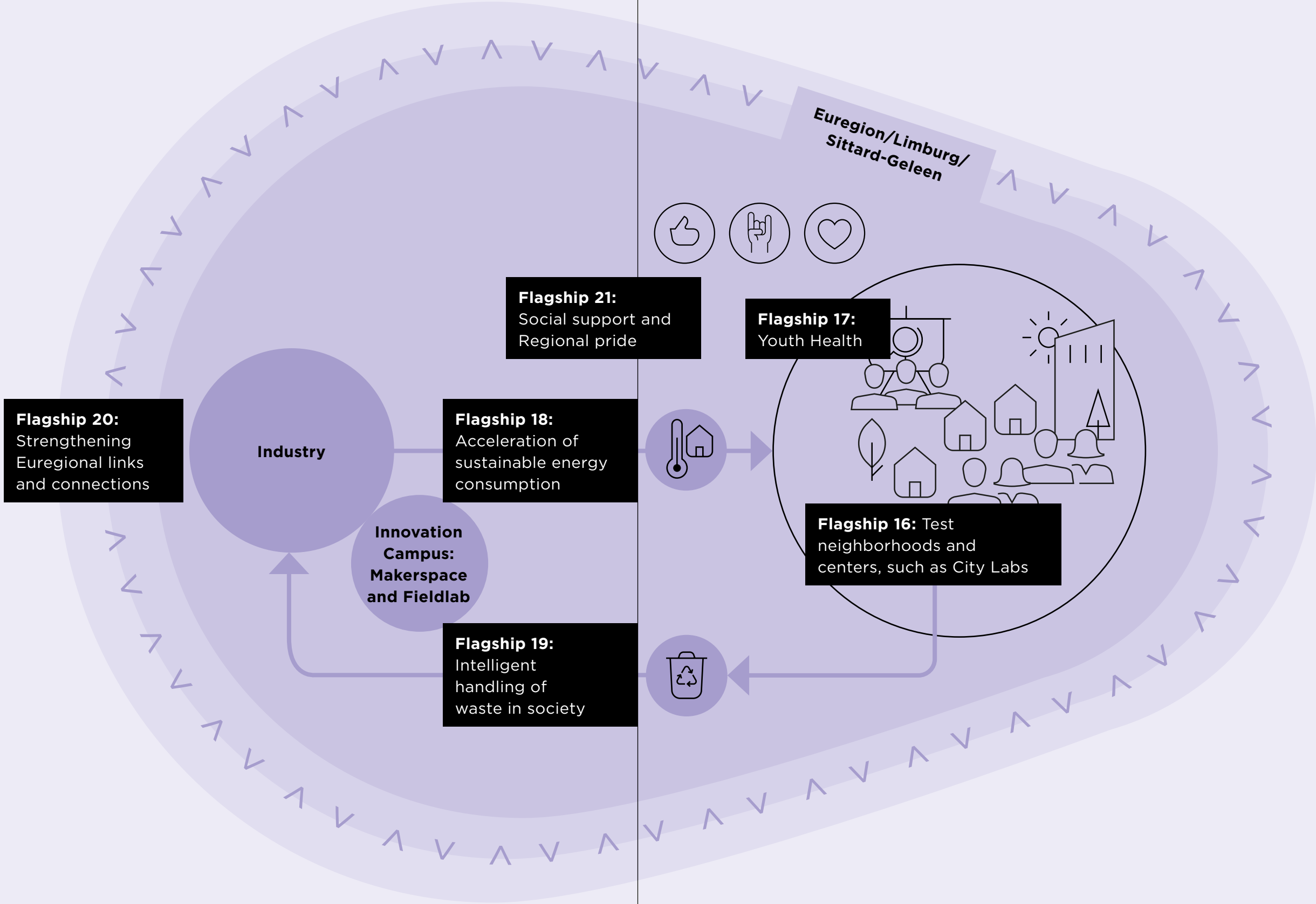
Limburg's Circular Policy Framework⁶¹ stresses the importance of cooperation between the many stakeholders, communicating best practices, sharing knowledge, bundle and streamlining communication on the circular economy. Setting up platforms for the purpose of community building is explored, and the Province will communicate proactively to its citizens about the energy transition and the circular economy.

The Dutch National Strategy on Spatial Planning (NOVI)⁶² confirms the importance of a good interplay between the various governmental organizations, societal institutions, businesses and citizens. This ensures that the various perspectives, initiatives and creativity are used in the process, enhancing the quality of solutions and mobilizing collective action and intelligence. It will be crucial to connect the CEAP's actions to the opportunities offered by this strategy.

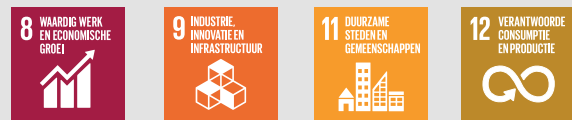
Sittard-Geleen is currently developing its 2030 Vision – this CEAP can provide useful input, and a future version of this CEAP can include elements of this 2030 Vision.

⁶¹ <https://ris2.ibabs.eu/Agenda/Details/Limburg/243933b4-e798-4f49-88d8-f1b0df6a6e90>
⁶² www.denationaleomgevingsvisie.nl/publicaties/novi-stukken+publicaties/HandlerDownloadFiles.ashx?idnv=1760380

Figure 12: Simplified visualization of the symbiosis between society and Chemelot



Test neighbourhoods and centers such as City Labs



Why?

Involvement of citizens in the development of Chemelot Circular Hub is crucial (see Flagship 21). Active participation can make this transition and all changes/(technical) innovations that come with it accessible for society and create awareness around the circular economy and can accelerate the process from (circular) idea to successful enterprise. Vibrant cities and attractive nature contribute to the attractiveness of regions and facilitate finding sufficient employees.

What?

Contribute to the transitions, while enhancing the quality of life in residential areas, by delivering:

- Two city labs in Sittard-Geleen, as pilot for the Euregion, are foreseen to create an inspiring environment in both Geleen (**Citylab Geleen Circular**) and Sittard (**Citylab Historical Sittard**), (see also Flagship 21).
- **Design competition** to re-vitalize Geleen's City Center ('**Het Verspreide Paleis**').
- **Experimental garden Smart City** will improve the public space in Zeeheldenbuurt.
- Recovery of the brook "Geleenbeek" and the adjacent area between Heerlen and Sittard (**Corio Glana**) and establishing an ecological connection **Graetheide** between (Grens) maas, Geleenbeek (via Middengebied), and Rode Beek (via Limbrichterbos).

How?

Citylab Geleen Circular covers five main themes (green and vital lifestyle, sustainable consuming, green energy, sustainable building/renovating and sustainable mobility) and will:

- Develop methodologies, tools, processes and a minimal (governance) structure required to build, maintain and improve a scalable and sustainable organization.
- Experiment on each of the lab's themes, delivering an approach which can be duplicated in other cities in the Chemelot Circular Hub, for example experimenting with the societal side of the circular waste value chain (Distribute & Retail, Repair, ReUse, Build and Use and Collection).
- Actively engage with stakeholders (citizens, industry, institutions and government) by continuous education, communication, and using new participation/engagement methods and tools to be developed, leading to a growing number of active and engaged Citybuilders (Stadmakers).
- Develop an open Geleen Circular data lab with a growing number of valuable real time circular insights.
- Develop and execute an incubator for early stage entrepreneurs in the 5 focus themes, including the society part of the circular plastic value chain.
- Develop and execute an active interaction & engagement program with the other citylabs and the parties on Chemelot to maximise synergy between the society and development aspects of the Chemelot Circular Hub.
- Organize activities for the young generation at all education levels. This can potentially include hackatons and/or circular design-and-build challenges.
- Cooperation with flagships 1 (Makerspace circular products), 2 (fieldlab circular processes), 7 and 21
- The Citylabs can be embedded in a national city-deal of the national Dutch Government and some 8 cities on the subject of social/impact enterprises. This will have the function of a (growing) national community in which knowledge will be spread about Citylabs as an accelerator for innovations for the circular society of the future.

The Citylabs can potentially translate the perhaps abstract transitions to concrete and meaningful activities for citizens (such as a focus on awareness of their energy use and exploring how they would deliver a say 30% reduction of their own energy use).

Citylab Historical Sittard focuses on the development of the historical centre of the Sittard area and includes 5 themes: authentic and fair-trade shopping, inclusive and sustainable lifestyle, arts & culture, walking and biking, urban green.

Chemelot could support '**Het Verspreide Paleis**' by jointly overthinking how the development and management-aspects of integrating the industrial world with the built environment can serve the mutual interests. Circular innovations can be tested and applied.

Experimental garden Smart City will be set up as a pilot project, implementing digital technology, testing new technologies/materials, using sustainable materials and implementing a climate adaptation approach. The project will establish a network to ensure its learnings can be replicated and results will be shared in the Climate Table Limburg.

Connecting the Human Capital Agenda with the City Labs:

To illustrate how the cooperation between the various initiatives can concretely look like, some (rough) ideas from a recent brainstorm on the connection between the Human Capital agenda (paragraph 2.3) and this flagship (Citylabs):

- Cooperate on collecting specific waste streams (PET bottles?) with youth in residential areas and convert into something attractive for these areas;
- Use each other's product streams (for example 3D print art, pump tracks for BMX-bikes (ongoing), hooks for climbing walls (ongoing) in City Labs);
- Jointly launch Circular City Game⁶³.
- "1001 Ideas for Limburg" festival for youth/citizens, facilitated by CHILL, aiming at practical circular solutions and develop and implement the best ideas in Acceleration Tables
- Citylab can showcase Chemelot developments to make these easily accessible for children/youth.
- Jointly work towards vertical greening of the city.

⁶³ <https://deweekvandecirculaireeconomie.nl/geslaagde-eerste-editie-nationale-hackathon-circulaire-economie/>

Youth Health



Why?

Currently, Limburg, especially the urban areas, scores lower on health than the rest of the Netherlands⁶⁴. Program 'Trendbreuk' (Trend-break) aims to overcome at least 25% of the persistent health gap, which already started at an increasingly younger age, between South-Limburg and the rest of the Netherlands as a whole, by 2030⁶⁵. Such health gaps have the tendency to be passed through to next generations and impact labor participation, education, social skills and physical and mental health⁶⁶. This is even more problematic in view of the expected vacancies in Chemelot Circular Hub until 2030 (see pillar 2). 'De Gezonde basisschool van de Toekomst' started in 2014 as part of Program Trendbreuk. The Limburg-pilot-project produced positive results in the context of research by Maastricht University. Children appeared to be healthier, with a lower BMI, and there was less bullying at school⁶⁷. Since Covid-19, important additional positive effect is a higher resistance.

What?

- Currently one primary school in Sittard-Geleen is working with the program 'De Gezonde Basisschool van de Toekomst'. The other 26 primary schools subscribe to the philosophy

- and approach and already implement a few parts of the program, but not to the full extent.
- Career guidance on secondary schools.

How?

- 'De Gezonde Basisschool van de Toekomst' do not just offer 'learning', but also 'learning to live'. Children receive healthy meals, parents are informed about a healthy life-style and there is more structural attention for exercise at school (children at least 1 hour per day active), including after-school activities. Inclusion of kitchen gardens is investigated. Teachers are actively involved, and each school has a project leader.
- The cooperating stakeholders (Trendbreuk/GGD, Primary Schools, PIW-MIK (Ecsplere) and Maastricht University) can cooperate with Chemelot (on Circular Competences (flagship 7) to explore how to enhance the program with the addition of circularity concepts, while maintaining the overall programs integrity.
- Further, the Program Trendbreuk is exploring providing guidance to the South-Limburg youth at secondary schools, helping them answering questions addressing who they are, what they can, what they want, and what motivates them – in cooperation with businesses, societal- and educational-organizations. This provides the youth with future perspective. The transfer from secondary schools to MBO schools is smooth, the MBO knows every student from his/her portfolio built up in this perspective – including internships and lifelike projects. In view of the need to fill many vacancies requiring (partially) circular economy competences before 2030, it is straightforward to cooperate with the similar initiative described in Flagship 7.

⁶⁴ www.limburg.nl/publish/pages/4723/missiegedreven_economisch_beleidskader.pdf

⁶⁵ www.ggdzl.nl/fileadmin/files/ggdzl/Documenten/Factsheets/Regionale_gezondheidsnota-2020-2023.pdf

⁶⁶ www.ggdzl.nl/fileadmin/files/ggdzl/Documenten/Factsheets/Regionale_gezondheidsnota-2020-2023.pdf

⁶⁷ www.nieuweoogst.nl/nieuws/2020/11/12/limburgse-kinderen-gezonder-door-lunch-en-beweegproject

Acceleration of sustainable energy consumption



Why

The current Chemelot production processes contain more than 3 PJ⁶⁸ residual heat (>70°C), which could in principle be used as heat in cities⁶⁹. While this residual heat currently has a fossil origin, with the transition to a fully circular and climate neutral site this would change, with – when set-up well – the citizen benefitting from this residual heat (mutual benefits).

What

The residual heat from Chemelot can be used in synergy with sustainable heat sources, like the current Biomass Energy Centrale (BES) which produces renewable electricity and heat on the basis of garden waste⁷⁰. This can build on the current heat networks in Sittard, which

currently deliver heat (and sometimes cold) to 1300 dwellings and 25 business connections⁷¹. South-Limburg's Regional Energy Strategy⁷² projects a total heat demand of >11 PJ in dwellings and > 4 PJ in utilities in South-Limburg in 2030, of which 2,7 PJ and 1 PJ in the Westelijke Mijnstreek. The Regional Energy Strategy further notes that 24% of the houses in Zuid-Limburg can currently be heated with residual heat > 70°C from Chemelot; this number is expected to increase due to improved insulation⁷³.

How

To prepare unlocking (part of) 450 TJ heat (from Chemelot) for Het Groene Net Zuid⁷⁴, Sabic's Olefins 4 plant in Geleen, which has residual heat of 95°C available, has placed a tie-in to unlock the heat recovery for Het Groene Net, without a further need for a maintenance stop (which typically happens every 6 years only)⁷⁵. This heat can be delivered to Geleen's districts Geleen-Zuid and Krawinkel.

By coupling the heat network from the Biomass Energy Centrale with the heat network from Chemelot (for back-up or peak demand), starting to harvest the residual heat from Sabic's Olefins 4 plant, and by adding more heat sources at Chemelot, and meanwhile delivering heat to buildings in an increasing part of Limburg, the impact of Het Groene Net can gradually increase. The business case of the expansion of Het Groene Net is challenging though and comes with risks, thus materialization of the plans above is far from certain⁷⁶.

⁶⁸ www.regionale-energiestrategie.nl/reszl/Default.aspx

⁶⁹ Considering neither the distance to cities nor the economic attractiveness.

⁷⁰ <http://besbv.nl/>

⁷¹ <https://ennatuurlijk.nl/warmtenetten/sittard>

⁷² www.regionale-energiestrategie.nl/reszl/Default.aspx

⁷³ www.regionale-energiestrategie.nl/reszl/Default.aspx

⁷⁴ www.chemelot.nl/nieuws/sabic-zet-belangrijke-eerste-stap-in-realisatie-restwarmtelevering-aan-het-groene-net

⁷⁵ www.chemelot.nl/nieuws/sabic-zet-belangrijke-eerste-stap-in-realisatie-restwarmtelevering-aan-het-groene-net

⁷⁶ www.limburg.nl/uitbreiding-groene-net-op-losse-schroeven

As next steps, the optimal concept will be further explored, addressing:

- Berenschot's recommendations⁷⁷.
- The targeted heat consumers (which areas; businesses, private individuals or housing cooperates).
- Their (future) heat demand and whether their design enables delivery of all the required heat – also in the winter).
- The likeliness of sufficient availability of residual heat from Chemelot in the future (after its transition to full circularity).
- Alternatives to deliver heat, for which South-Limburg's regional energy strategy⁷⁸ mentions heat storage, aquathermal heat, solar collectors and heat from biomass.

Potentially the risk (initial investment) can be reduced by using an innovative salt-based heat-battery – rather than pipelines – to transport heat to the buildings connected. This approach needs to be further explored, scaled-up and validated.

Flagship 19

Intelligent handling of waste in society



Why

The Westelijke Mijnstreek aims to reduce the amount of non-recycled municipal waste to 100 kg waste per person in 2025, 30 kg in 2030 and zero in 2050. By increasing (regional) recycling rates, generation of waste can be eliminated, and materials can be preserved the region contributing to full circularity – in Limburg and in the broader Euregion.

What:

- Waste Cooperation Limburg (ASL) stimulates circularity;
- Meeting places, like the Repair Café's in Munstergeleen and Sanderbout, create social awareness of the importance of circularity while strengthening social cohesion.

How

- 'Waste Cooperation Limburg' (ASL) is preparing a program including:
 - Circular tendering of main waste stream(s) (residual waste, organic waste, PMD; in total ~300 kton⁷⁹). This innovative tendering method (Rapid Impact Contracting⁸⁰) includes flexible processes, enabling applying new solutions when they become available⁸¹, and municipalities cooperating at scale to sort their waste and convert it into useful materials for new applications within the province of Limburg⁸².
 - Raw material management, (regional) closing of raw material value chains for household waste by chain management, advocacy and business development
 - Bundling the municipal resources in a circular platform cooperating with other actors on specific developments in the multi-helix program.
- Building on the experiences with the Circular Craft Center pilot in Maastricht, additional meeting places could be created, also aiming at youth.
- The circular narrative can be shared stronger with society, and plans are being developed to stimulate local entrepreneurs, schools and residents to separate waste, enabling circular processing.

⁷⁷ Berenschot evaluated the first period of Het Groene Net in: Berenschot, Eindrapportage Verdiepingsonderzoek naar financiën en beheersing, January 11th, 2021.

⁷⁸ www.regionale-energiestrategie.nl/documenten/handlerdownloadfiles.ashx?idnv=1714358

⁷⁹ <https://online.ibabs.eu/ibabsapi/publicdownload.aspx?site=Limburg&id=a1d6cc2f-f874-45db-8a2c-32b49c0c1c56>

⁸⁰ <https://online.ibabs.eu/ibabsapi/publicdownload.aspx?site=Limburg&id=a1d6cc2f-f874-45db-8a2c-32b49c0c1c56>

⁸¹ <https://afvalsamenwerkinglimburg.nl/limburg-ambieert-rol-als-circulaire-grondstoffenregisseur/>

⁸² <https://online.ibabs.eu/ibabsapi/publicdownload.aspx?site=Limburg&id=a1d6cc2f-f874-45db-8a2c-32b49c0c1c56>

Flagship 20

Strengthening Euregional links and connections



Why

As the Dutch part of South-Limburg is relatively small, connection with the Euregion widens the scope and possibilities of Chemelot Circular Hub. The Charter Energy Transition Small- and Medium-size Enterprises (SMEs) can help SMEs to meet the Chemelot Circular Hub's – future – expectations from their partners.

What

- Charter Energy Transition SMEs stimulates awareness, knowledge sharing and offers contact with experts to support SME's in the energy transition; expanding this Charter to the full Euregion is explored.
- Improve Euregional public transport infrastructure.

How

- Three business parks in Limburg (Business-park Stein-Elsloo, Krawinkel or Bergerweg in Sittard-Geleen and De Koumen in Heerlen) have the pilot status in Charter Energy Transition SMEs; expansion of the scope of the Charter to the Euregion is explored.
- Potentially: Experimental self-driving taxis between knowledge institutes/city labs/centers of excellences.

Flagship 21

Social support and regional pride



Why

Communication and cross-fertilization between the inhabitants of Limburg and Chemelot Circular Hub is key for many reasons:

- Inhabitants, institutions and entrepreneurs:
 - Are more involved in the circular processes (awareness of what circularity means, sorting household waste, testing recycled products etc.).
 - Will provide new perspectives, key in a transition that still needs to be jointly invented and developed, and thus increases the quality of the transition.
 - Will improve the local democracy and inform local policy making.
 - Can be early adaptors in many of the other Chemelot Circular Hub flagships.
- The transition towards a circular society will impact the inhabitants and teaming up and communication builds the understanding of what happens at Chemelot industrial park and Brightlands Chemelot Campus, and thus contributes to regional pride, and consequently Chemelot's 'license to operate'.
- Many inhabitants work, directly or indirectly, at or for Chemelot.
- It accelerates the transition and reduces the likeliness of criticism and resistance, often leading to long decision processes.

Limburgs Circular Economy policy framework wants to actively communicate the circular narrative to citizens, townships, companies and other organizations, engaging them to act proactively playing an exemplary role⁸³.

What

This Flagship is a central cornerstone of Chemelot Circular Hub. It aims to:

- Make the transitions an activity that all stakeholders jointly undertake, with a crucial role for citizens and youth, engaging in an open, transparent, and sometimes vulnerable dialogue, jointly shaping and jointly owning our future.
- Improve the image residents (especially the young generation) have of Chemelot, widen the communication focus from just external safety/disturbances to also include the intention to move from linear to circular.
- Increase confidence in the necessity of the transition ("the right thing to do"), not only from environmental perspective, but also from the perspective of regenerating the community and its (working) population.

How

- Set-up a Youth Circularity Council. This forum could discuss this CEAP and strengthen its next updates, and immediate next steps, and support the communication efforts and messaging to other citizens. Its members could act as the citizens voice and as Circularity ambassadors to other citizens. They could strengthen the activities and add further connections/initiatives.
- The Youth Circularity Council could additionally cooperate with Flagship 17 and with the Human Capital Agenda Flagships 7-10, and help to preserve young talents for the region. They could regularly link with young people in the climate movement, with BCC's Young Professionals network and with the educational institutes.

⁸³ <https://ris2.ibabs.eu/Agenda/Details/Limburg/243933b4-e798-4f49-88d8-f1b0df6a6e90>

- Communicate incessantly about circularity and Chemelot Circular Hub, its 'case for change', its vision, the CEAP (in a more accessible version), immediate next steps, using different communication modalities:
 - Inform citizens about circularity, the impact of Chemelot Circular Hub (flagship 6), advantages and disadvantages (from a personal view), building on the City Labs (flagship 16).
 - Help citizens and young people to make their circularity ambitions concrete ("Chemelot Circular Hub helps me to become more circular").
 - An accessible version of the investment agenda – in understandable language
 - A version of the investment agenda aimed at the youth (primary school, secondary school).
 - Communicate and create pride on the innovations pursued and delivered in Flagships 1-5, the achievements of the Human Capital agenda and the further development of all other Flagships.
 - Create pride on the Chemelot Circular Hub transitions and use these as a lever to attract new people to the region and provide people with stories to tell about their Chemelot Circular Hub!
- Circular events (in-person and virtual).
- Residents participation: Creating a setting in which people can act themselves in a circular manner or participate and interact in the transition.
- Potentially explore whether to set up an infrastructure enabling citizens to crowd-fund (innovative) start-ups at Chemelot Circular Hub.

- Potentially Chemelot's safety staff could deliver broad safety/sustainability/circularity-at-home trainings to the citizens living nearby – delivering Chemelot's safety thinking to citizens nearby; these trainings could also provide an apt platform to discuss safety at Chemelot. A network of safety ambassador residents could be set-up.
- Learning from, or singing up for, the European Climate Pact⁸⁴, could be considered too.

This citizen participation/engagement will need to discover what works and what doesn't and requires an innovative mindset, exploring new ways to cooperate – and every now and then accepting that innovation can come with failure.

⁸⁴ https://europa.eu/climate-pact/about_en: "The Climate Pact is an opportunity for people, communities and organisations to participate in climate action across Europe: Learn about climate change, develop and implement solutions, connect with others and maximise the impact of these solutions. As part of the European Green Deal, the Pact aims to become a lively space to share information, debate and act on the climate crisis, and offer support for a European climate movement to grow and consolidate."



Action List Chemelot Circular Hub

The table on the next page presents the key actions described above. These are the building blocks for Chemelot Circular Hub's actions. In the time to come, the Chemelot Circular Hub partners will build a future, sustainable society for all, each partner using its own contribution and building blocks. This action list is dynamic and will be updated regularly.

The projects mentioned here demand a commitment from the business community as well as authorities and other stakeholders in the region, on behalf of the national government and the European Union; this includes:

- Investments from the Regional Government (Limburg as well as neighbouring regions in Germany and Belgium) to foster the enabling infrastructures for the circular economy (e.g. for logistics of biogenic and waste feedstock).
- Public funding from European Structural and Investment Funds (e.g. INTERREG), to support cross-border collaboration programmes fostering a Euregional circular economy (e.g. for realising regional logistics and standards for biomass mobilisation, waste collection, and joining forces towards a critical mass of biogenic and waste feedstock or for fostering citizens engagement cross-border).
- Public funding from national and EU (Demonstration Energy & Climate Innovation (DEI+), Just Transition Fund, Horizon Europe, European Recovery and Resilience Fund, Innovation Fund, LIFE etc) research programmes to carry out research, development, demonstration and first-of-a-kind commercial pilots, to develop the enabling technologies, non-technological solutions and business models for the Circular Hub and to overcome the key bottlenecks – such as longer term ROI related to innovative CO₂ reduction investments – to realise the circular economy and the ambitions of this CEAP.

- Public funding from national and EU (e.g. Erasmusplus, Marie Curie skłodowska, European Social Fund etc) to educate, train and foster the professionals and citizens for the future circular economy.
- Public and private finance (e.g. Invest Europe, European Innovation Council, European Institute for Technology, COSME etc) to unlock and support private investments towards large scale infrastructure investments in the Regional Circular Economy (e.g. roads, multimodal transport solutions, pipelines etc) as well as to foster a vibrant cleantech entrepreneurial eco-system (e.g. through seed funds and vouchers to support start-ups and scale-ups to further develop, test and launch circular economy solutions that contribute to closing the loops in the circular economy).
- The Dutch national support schemes Accelerated Climate Investments Industry (VEKI), Support Sustainable Energy (SDE++) and the Growth Fund (Groefonds).

A CEAP Funding strategy aims to leverage on all funding sources, targeting an optimal synergy between private – regional – national and European public funding and finance, towards realising the goals. The strategy will be designed and continuously updated according to the dynamic and continuously evolving funding landscape.

Achieving the Chemelot Circular Hub ambitions will require a minimum investment of € 4 billion over the next ten years (2020-2030). This involves additional public-private investments, in other words, on top of those that companies or governments already intend to make in the greening of production processes, creating infrastructure or introducing new applications and/or competencies.⁸⁵

⁸⁵ Based on Investment Agenda 2020- 2030, www.chemelotcircularhub.com/en#download; Chemelot Circular Hub is working on a more detailed view on these costs, including yearly costs (CAPEX and OPEX).

Flagship	Project
1 Circular Design	1.1 Fieldlab/Makerspace Circular Design
	1.2 Circular Packaging
	1.3 Recycling of composites
	1.4 Circular building and construction materials
	1.5 Recycling of technical plastics
	1.6 Textiles
2 Waste as raw material source for carbon and hydrogen	2.1 Understanding waste streams and (pre)processing
	2.2 Waste to cracker feedstock: pyrolysis
	2.3 Waste to hydrogen
	2.4 Waste to cracker feedstock: Solvolysis/pyrolysis
	2.5 Waste to cracker products
	2.6 Waste to carbon: Pyrolysis of tires
	2.7 Waste to monomers: PET/PA
	2.8 Waste to plastics: Solvolysis
	2.9 Apply CO/CO ₂ : Gas Fermentation
	2.10 Apply CO/CO ₂ : Fischer Tropsch
	2.11 Fieldlab Waste as Feedstock
	2.12 Chemical recycling development centre
	2.13 Supporting technology
3 Biogenic raw materials	3.1 Biomass mobilization to bulk chemicals
	3.2 Biomass mobilization to syngas
	3.3 Biomass to hydrogen
	3.4 Biomass to bionaphtha
	3.5 Biomass to ethanol and butadiene
	3.6 Biomass lignin to BTX
	3.7 Biomass sugar to FDCA
	3.8 Biomass to C6: levulinic acid
4 Reduction of non-CO₂ emissions	4.1 Circular water
	4.2 Microplastics
	4.3 Nitrogen
	4.4 N ₂ O emission reduction
5 Electrification	5.1 Plasma technology
	5.2 Academic plasma Centre
	5.3 Rotodynamic technology
	5.4 Cracker of the Future
	5.5 Electrification of high temperature processes
	5.6 Demonstration 20 MW electrical steam boiler
6 Integration	6.1 Institute for Assessment of Circular Economy Actions
	6.2 Model towards zero GHG emissions and fully circular/renewable 2050
	6.3 Digital twin
	6.4 Outreach to LE and SME's on innovations
7 Strengthening the education chain	7.1 Master Curricula Circular Engineering
	7.2 Master Circular Urban Redesign
	7.3 Bachelor Circular Engineering & Science
	7.4 AD Engineering
	7.5 Communities of Practice for process industry
	7.6 Centre of Expertise Circular Engineering
	7.7 Curriculum – De-assembly end-of-life products, sensors in manufacturing processes, education innovation industry 4.0
	7.8 Circular Supply Chain Management
	7.9 English language Applied Computer Science/AI, Business Engineering and Applied Science
	7.10 Makerspace Circular Materials
	7.11 Sustainable Process Technology
	7.12 Circular building materials
	7.13 Broaden cooperation activities
	7.14 Hybrid teachers

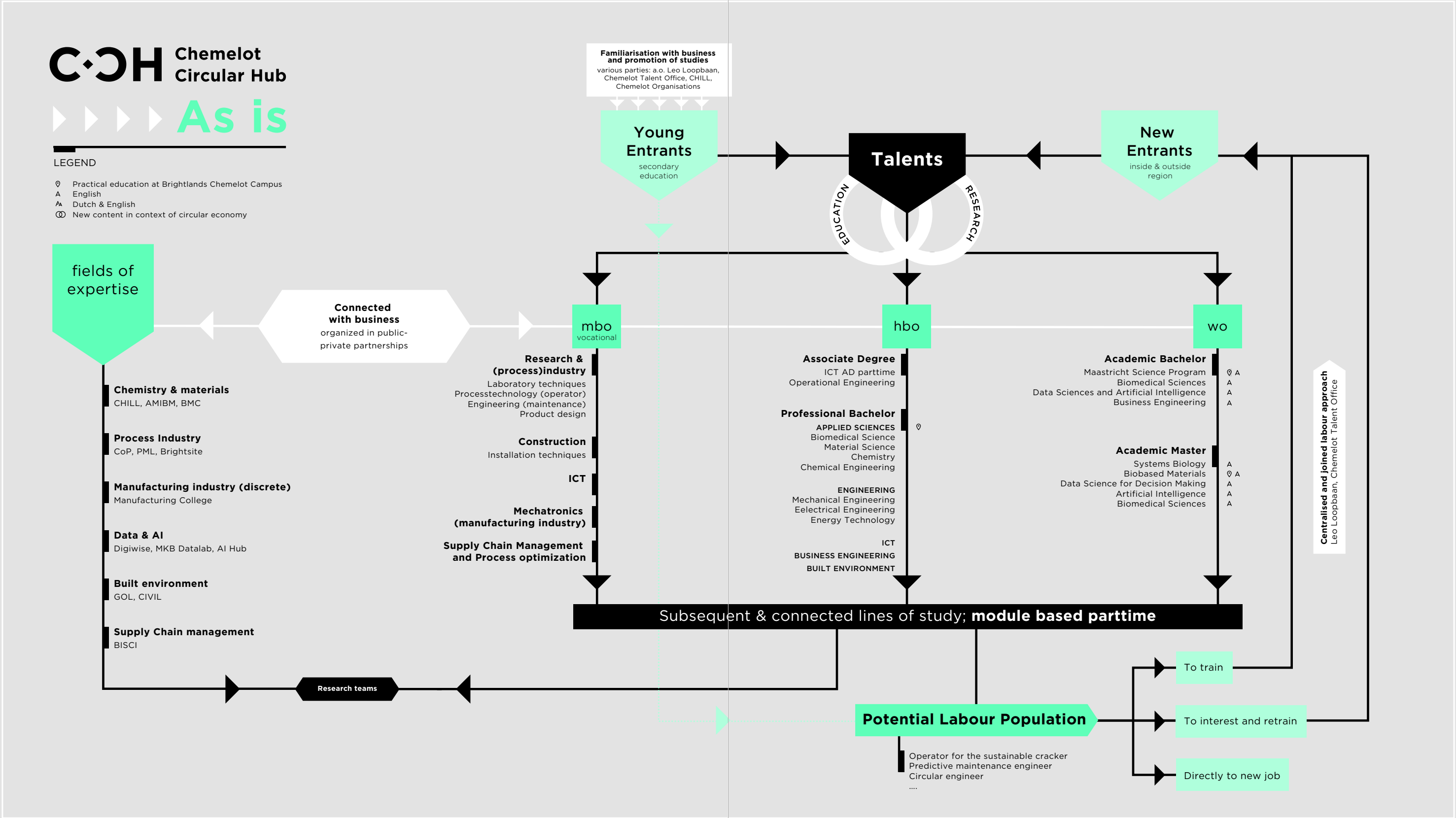
Flagship	Project
8 Employability and involvement of people	8.1 Attract talent
	8.2 Expand activities
	8.3 Talent Office
	8.4 Experience Approach
	8.5 Youth
	8.6 Youth – connect with existing initiatives
	8.7 1:1 Recruitment
	8.8 Regional Circular Talent Office
	8.9 Reskill current workforce
9 Real estate for education and research	9.1 Circular Engineering
	9.2 Educational Space Applied Science and Engineering
	9.3 Fieldlab
	9.4 Makerspace
	9.5 Industry 4.0/ICT space
	9.6 Renovation Labs Zuyd Heerlen
	9.7 International Circular Building Academy
10 Setting up labs and professional premises	10.1 Furnishing and equipment circular engineering
	10.2 Furnishing and equipment or scaling up in process industry
	10.3 Furnishing and equipment for processing of materials
	10.4 Mechanical plastic recycle line
	10.5 Chemical synthesis lab
11 New investments and the establishment of new circular activities	11.1 Satellite sites
	11.2 Redevelop areas + Downstream satellite sites
	11.3 Expand utilities
	11.4 Circular water --> refer to flagship Ω
12 Security of supply of circular and biogenic raw materials	12.1 Raw material program Chemelot 2050 Renewable trading company
13 Security of renewable energy supply	13.1 380 kV
14 Adequate capacity for logistics infrastructure	14.1 Pipelines
	14.2 Hydrogen network
	14.3 Harbour Stein and multimodal corridor
	14.4 Rail transport
	14.5 Road transport
15 Urban-industrial symbiosis	15.1 Mobility
16 Test neighbourhoods and centers such as City Labs	16.1 City labs
	16.2 Pilot Garden Smart City – Zeehelden buurt
	16.3 Ecological connection Graetheide
	16.4 Het Verspreide Paleis
	16.5 Corio Glana Highlight
	16.6 Geleen Zuid
17 Youth Health	17.1 Healthy primary school of the future
	17.2 Career orientation and guidance
18 Acceleration of sustainable energy consumption	18.1 Het Groene Net
19 Intelligent handling of waste in society	19.1 Waste Cooperation Limburg
	19.2 Meeting places
20 Strengthening Euregional links and connections	20.1 Charter Energy Transition Limburg
	20.2 Self-driving taxis
21 Social support and regional pride	21.1 Citizen participation and Circular events

Appendix

Annex 1

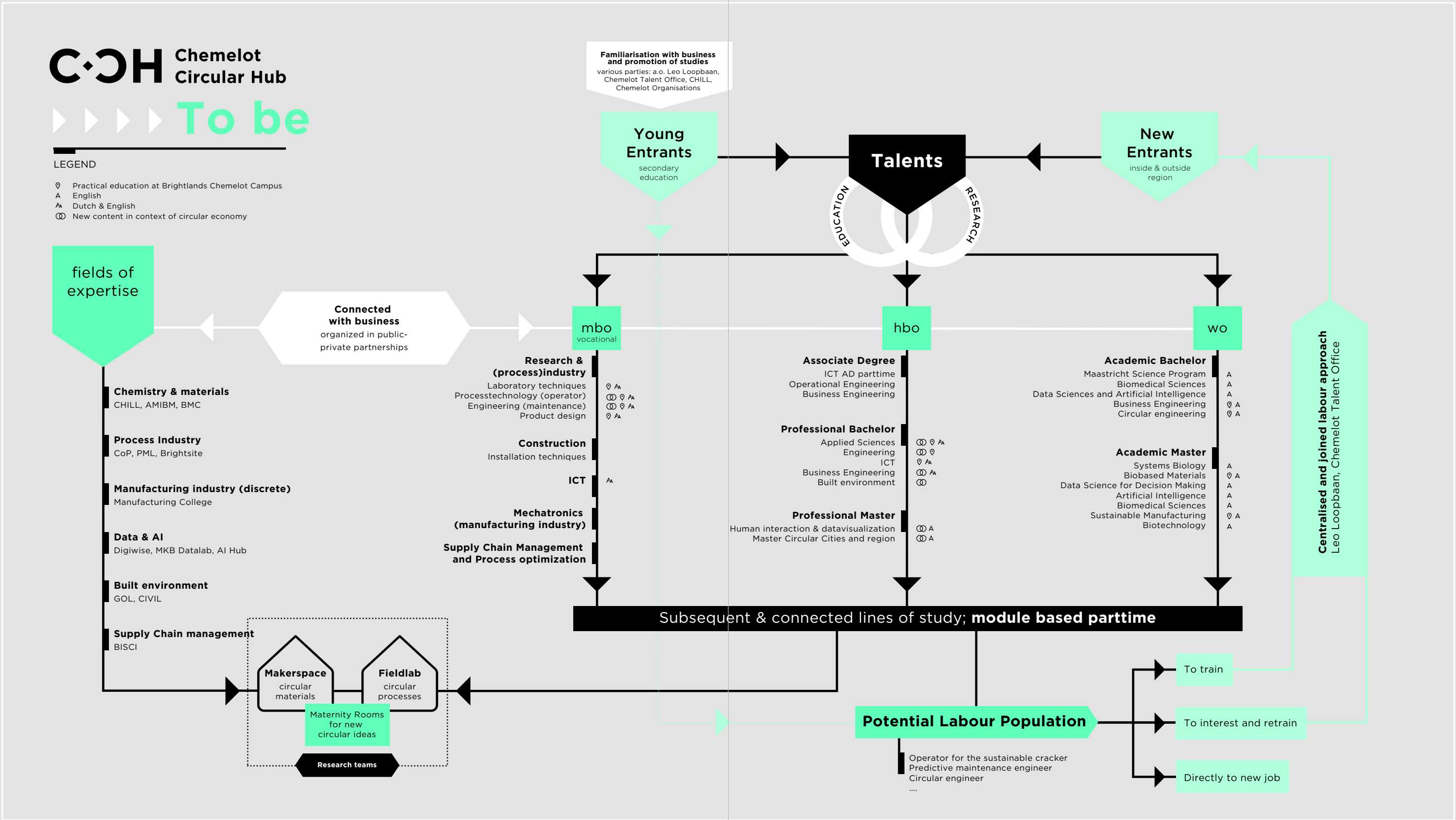
“As is” and “To be” for Pillar 2

The visuals below visualize the current situation, and the aimed for future state for Pillar 2 in much detail.



Annex 1

“As is” and “To be” for Pillar 2



Annex 2

Sustainable Development Goals assessed for their fit with Chemelot Circular Hub’s flagships

The Sustainable Development goals assessed with the quick estimate are summarized in the table below.

Logo ⁸⁷	Key point of Sustainable Development goal	Logo	Key point of Sustainable Development goal
	Ensure healthy lives and promote well-being for all at all ages		Build resilient infrastructure, promote inclusive and sustainable industrialization, and foster innovation
	Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all		Make cities and human settlements inclusive, safe, resilient and sustainable
	Ensure access to affordable, reliable, sustainable and modern energy for all		Ensure sustainable consumption and production patterns
	Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all		Take urgent action to combat climate change and its impacts

⁸⁷ Logos from: <https://sdgs.un.org/goals>. Not all SDG’s have been assessed.
SDG’s coverage is broader than included in this table / in the assessment.

