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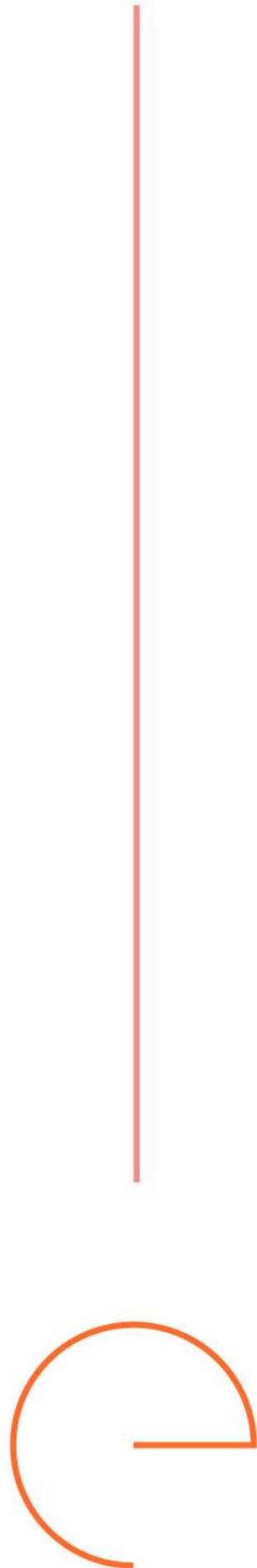
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Foreword

Luxembourg is in transition, not because this consultation declares this, or because of the Paris agreements, or because of COVID19. Luxembourg is in transition because the world's future is uncertain. We see increasing signs that the current way we organise, work and think about our energy, mobility, water, waste, and food systems is no longer sustainable. The CO2 levels of our fossil fuel-based economy are symptoms of the unsustainability of our societal systems. 'External trends' like COVID19 forced Luxembourg into reckoning with these dependencies. At the same time, transitions are already well underway. Diverse societal actors are increasingly aware of the urgency and are developing alternative initiatives. For example, communities that prohibit cars in their streets transform their street into a living room, where children can play safely and where parking places become a green oases for butterflies and insects.

The Department of Spatial Planning of the Ministry of Energy and Spatial Planning recognises that conventional planning approaches will not be sufficient in times of transition. They have therefore commissioned an urban-architectural and landscape consultation to illustrate how spatial design and planning can facilitate a transition towards a zero-carbon emission and a resilient society in 2050. Including external expertise helps to expand your perspective on the transition and challenge biased and short-sighted practice. For example, rather than exclusively focusing on the CO2 neutral target this approach considers this one aspect of the transition towards a regenerative resilient Luxembourg functional region.

To this end, our consortium comprises a multidisciplinary approach. We believe that a design-lead process fundamentally requires collective understanding of transition. From this, we consolidate a clear and imaginative spatial imaginary, which we then test through a rigorous methodology that combines the needs and opportunities per theme and the synergies amongst them. We communicated these efforts and learnings in our report for Phase 1 where we expose why, how, and sketch what we expect to obtain in future. In Phase 2 we have tested and adjusted our methodology achieving a governance driven vision, where we aim to promote (re)generation at the same time than providing a decarbonization tool towards collaborative decision making.



Beyond Lux(e)!

Phase 01:
Towards
Ecotopia

1

7

Analysis

2

15

(re)generation
matrix

3

85

Decarbonization
tool

4

97

Contents

Governance
scenarios

5

131

Ecotopia
scenario

6

167

Next steps

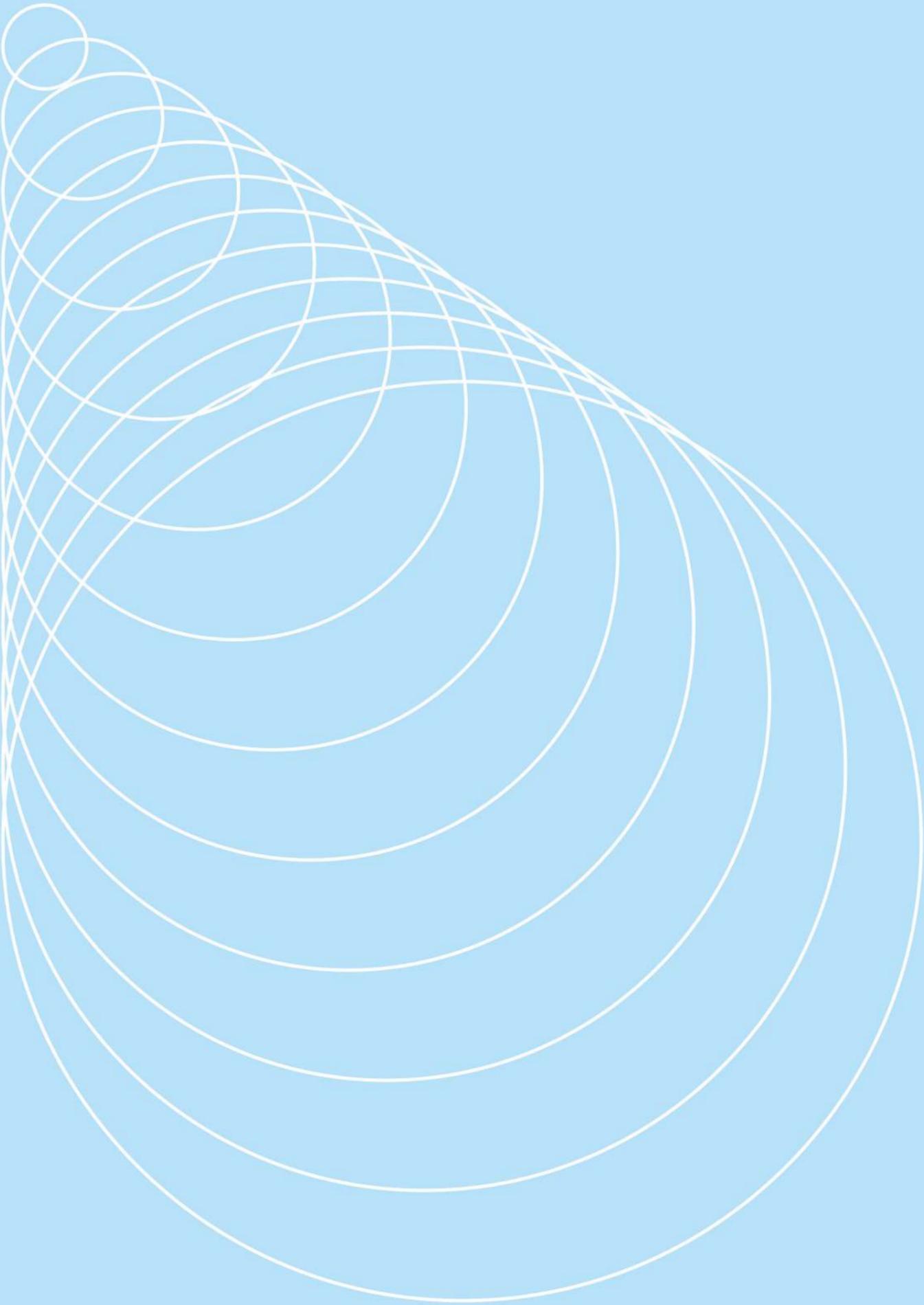
7

217

Colophon

8

233



Phase 01: Towards Ecotopia

Beyond zero carbon: (Re)generation

The five themes

Governance driven approach

From linear to iterative methodology

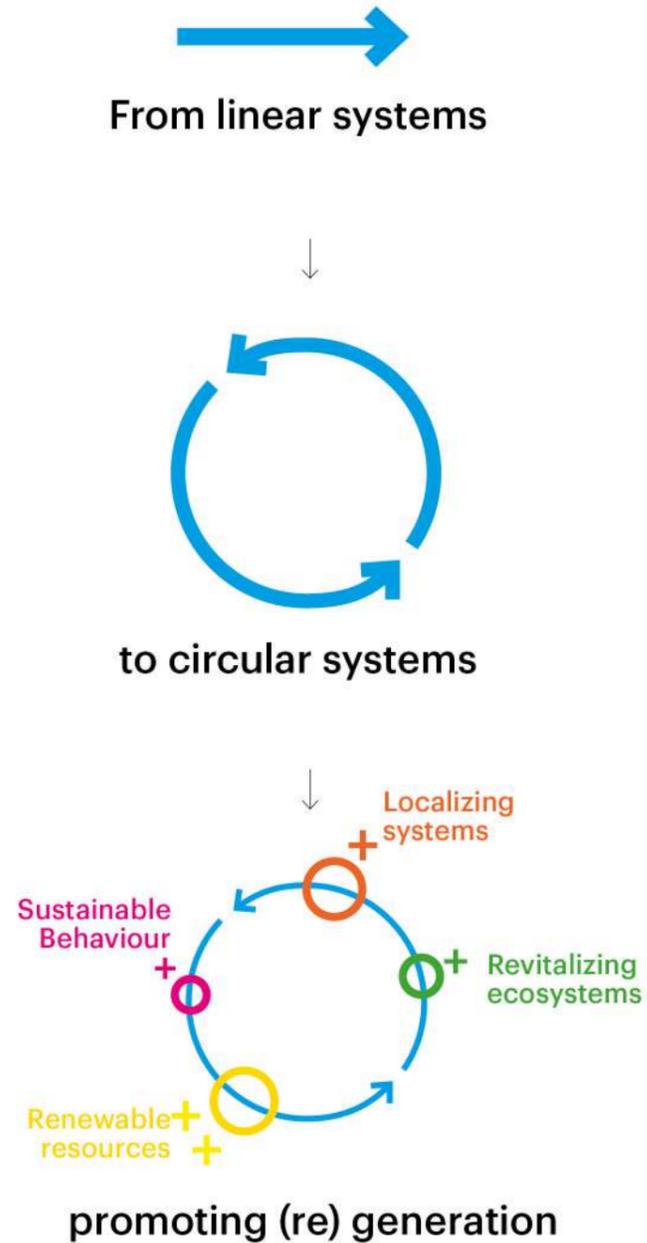
From Great Region to Functional Area (lux+)

1

Beyond zero carbon: (re)generation

The approach and methodology to achieve targets for Luxembourg Functional area propels a shift that surpasses zero carbon targets to achieve comprehensive regenerative transition. To understand the inherent value and impact of this methodology, it is integral to understand it is not only in spatial or quantitative outcome terms,

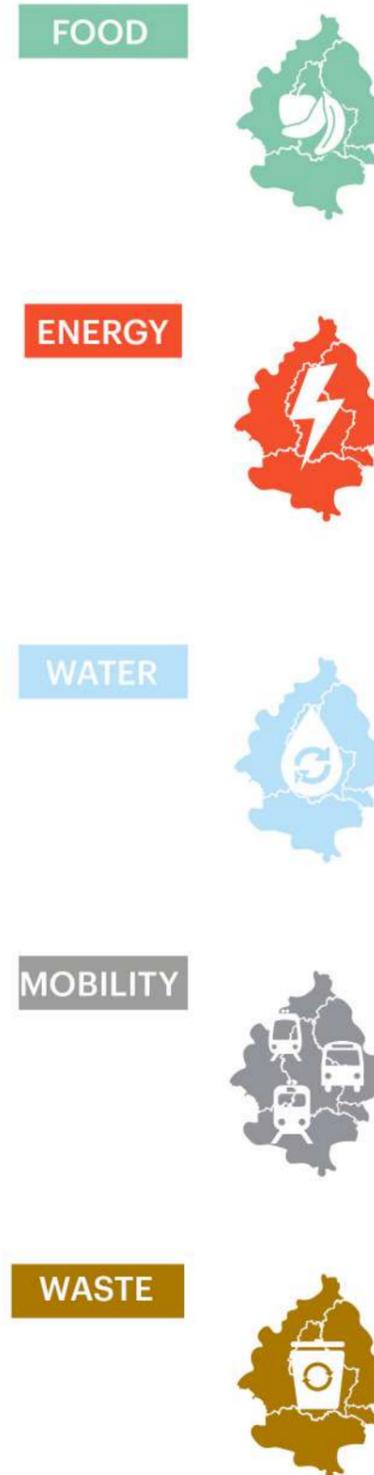
but also as a qualitative process. By definition, regeneration moves beyond even circular principles, aiming to generate synergies, and connections to other systems in place to support full integration.



The five themes

From phase 1, we have analyzed that for the decarbonization transition we would need an integral understanding of what themes are bringing more carbon emissions, and how do they relate to each other.

Due to the nature of our multidisciplinary team, we allocate a diverse landscape of experts in diverse themes. All of them integrated in land. Therefore, as part of phase 1 and continuation in phase 2, we have taken the five themes and their connection on land as a way to have an holistic approach on each theme.



Governance driven approach

Our design-led transition-governance approach will help the Department of Spatial Planning of the Ministry of Energy and Spatial Planning identify transformations in progress. This will determine how these can be included as regenerative metrics that work alongside CO2 reduction. We developed this **design-led transition-governance approach within a consortium that consists of experts of each theme, as well as landscape, design, and transition governance experts.**

Our consortium believes that our role as experts and designers must also change due to transition dynamics at play. This informs the co-production of this methodology, which establishes the starting point of a co-production process engaged with local actors.

Therefore, we aim to facilitate the transfer of this approach as part of the upcoming phases. We view our role as follows:

1. **We build a desirable future image of a regenerative and resilient Luxembourg functional region in 2050 (backcasting).**
2. **We supplement this desired future image with metrics that are accompanied by trade-offs according to positive and negative impact (forecasting);**
3. **We include the phasing and links between the different systems in transition. These are food, energy, water, mobility and waste which are in transition simultaneously.**

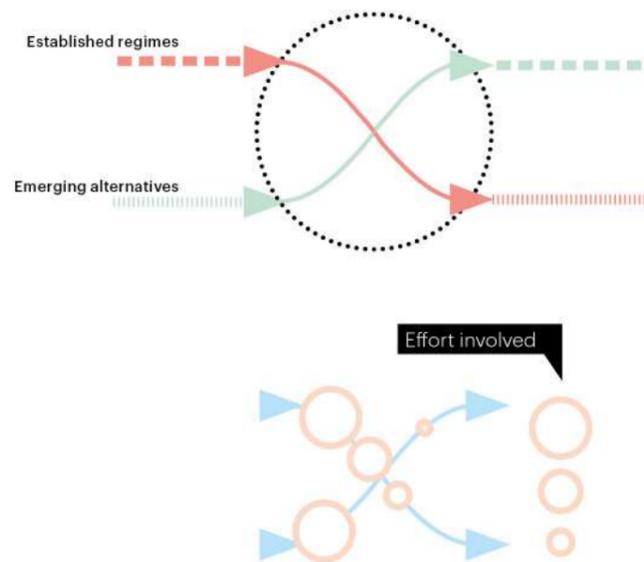
We will deliver a process design that has begun to be implemented and can be continued to support the emerging alternatives. This can become the standard and facilitate the phasing out of unsustainable practices. This can be accomplished by including actions already underway within the interventions of the process.

Mang, P., & Reed, B. (2020). Regenerative development and design. *Sustainable Built Environments*, 115-141.

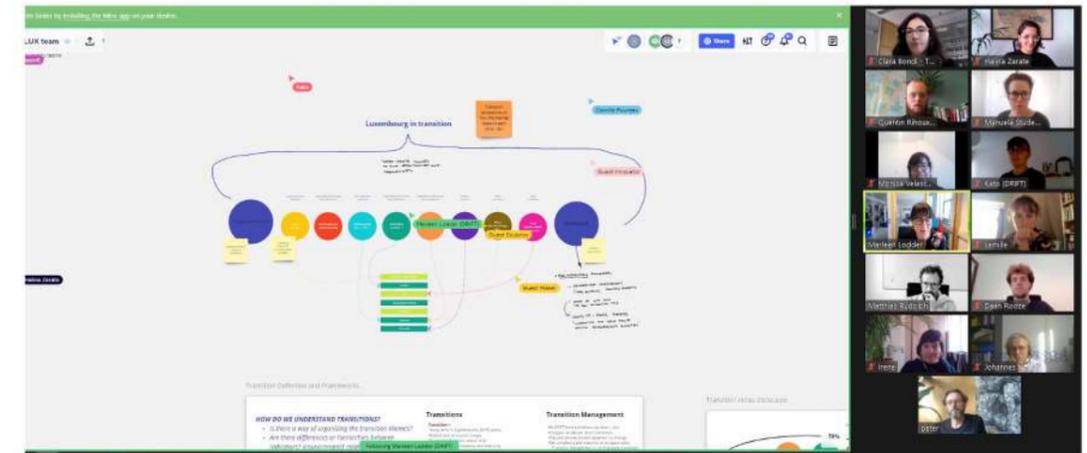
Loorbach, D., Frantzeskaki, N., & Avelino, F. (2017). Sustainability transitions research: transforming science and practice for societal change. *Annual Review of Environment and Resources*, 42.

Grin, J., Rotmans, J., & Schot, J. (2010). On patterns and agency in transition dynamics: Some key insights from the KSI programme. *Environmental Innovation and Societal Transitions*, 1(1), 76-81.

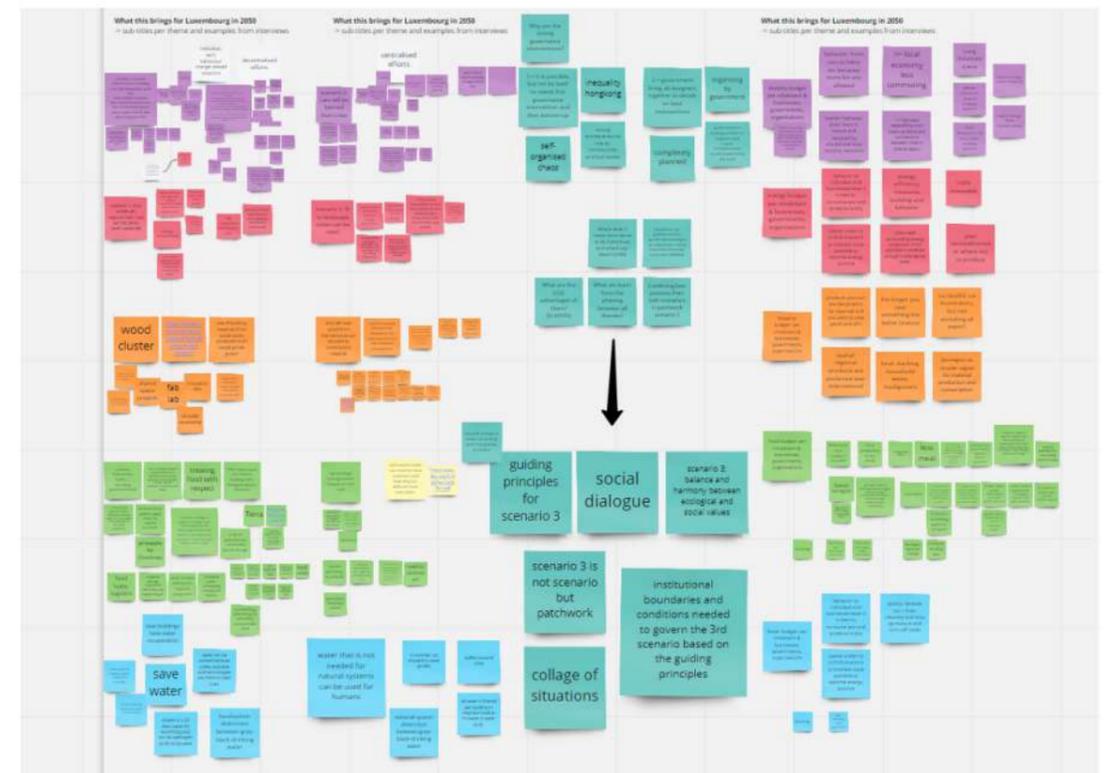
Geels, F. W. (2005). The dynamics of transitions in socio-technical systems: a multi-level analysis of the transition pathway from horse-drawn carriages to automobiles (1860-1930). *Technology analysis & strategic management*, 17(4), 445-476.



Loorbach et al (2017)



Screenshot on workshops of the full consortium



Screenshot on conclusions on interviews process

From a linear to an iterative methodology

In Phase 1, the methodology we applied was linear, with each step building on the one previous, to reach a desired effect. However, key transformations on the different themes (food, energy, water, mobility and waste) are currently underway. By applying an iterative methodology, we can implement the governance-driven approach, consolidating the transformation effort with both a top-down, and bottom-up strategy, makes space for adaptation and adjustment.

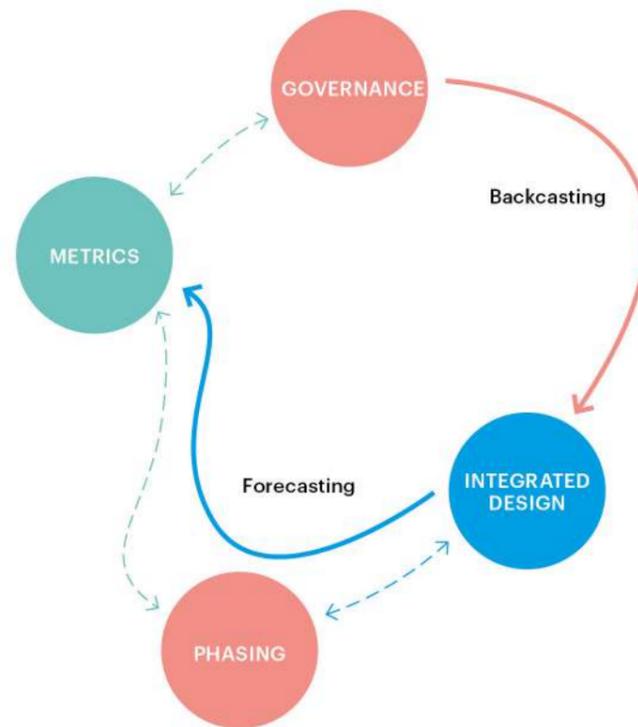
The change it brings will not come from a linear methodology, but rather a continually developing one.

To this end, the methodology supports an adaptable and integrated approach that is designed to enable effective collaboration beyond the scope of this competition to incorporate a broader community of experts, as well as initiatives and activities of related entities. This relies on an understanding that the nature of this transition is iterative.

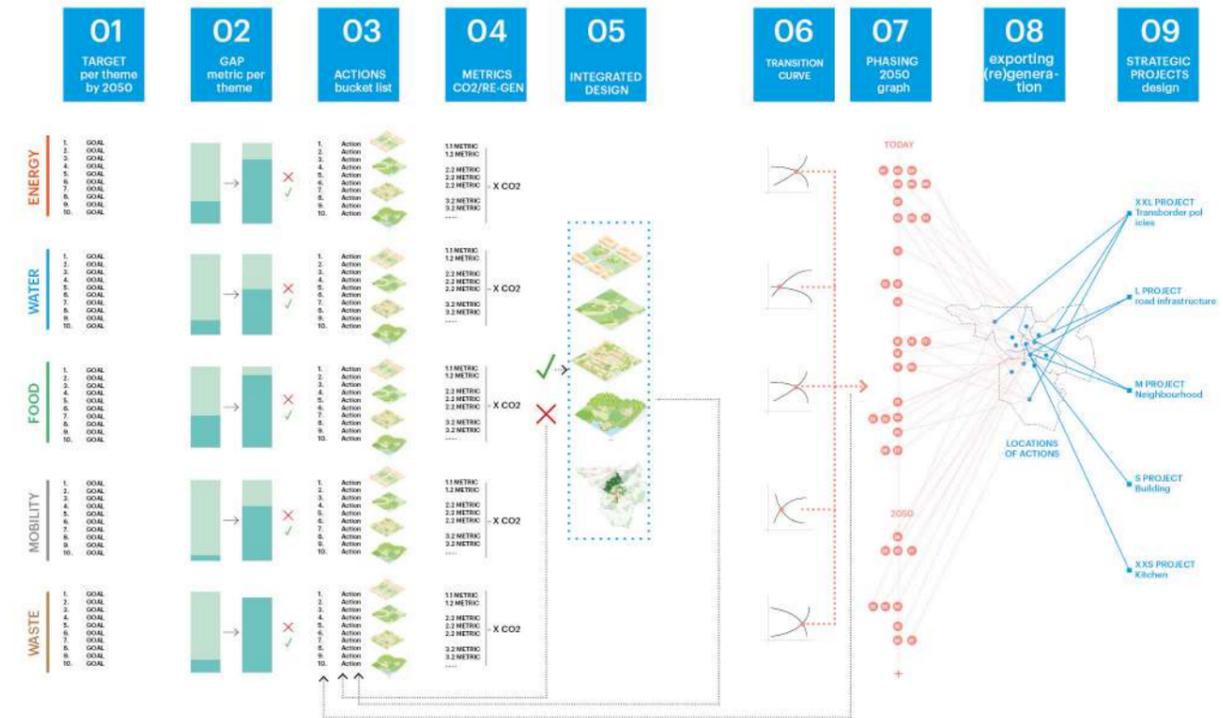
During Phase 2, societal actors begin to enter the equation. This involves:

- Participatory visioning with retrospectives, and governance strategies
- Co-production, by empowering local actors to ensure and empower them that they play an integral role in the transition
- Client involvement, to help take on their new role and by gathering knowledge in order to institutionalize emerging resilient, regenerative practices

It is imperative to consider that this methodology is not exclusively a vision or goal, but instead, it is a process. The nine steps outlined bring this process towards a vision with collaboration, adaptability, and systemic rigor as foundational imperatives.



Linear



Iterative



From greater region to functional area

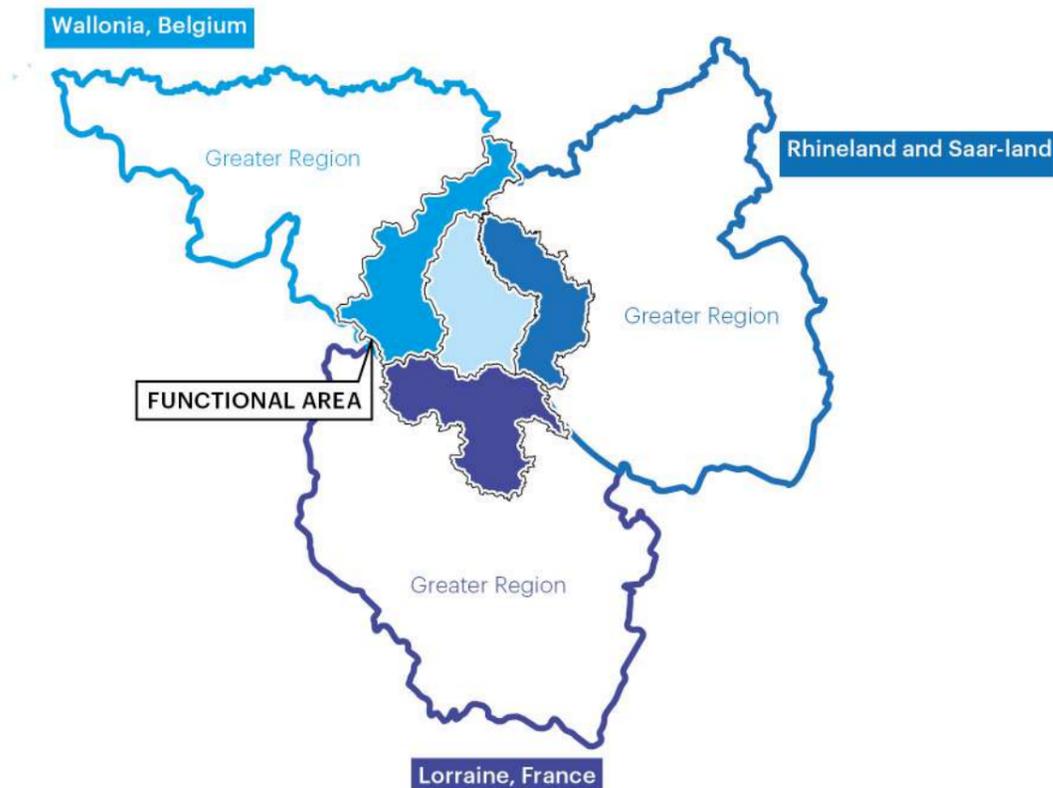
The scope of work in Phase 1 focused on Luxembourg's greater region. In Phase 2, alongside the client organization and other teams, we will endeavour to generate a common delimitation: the functional area.

This area focuses on Luxembourg the country, as well as its more immediate cross-border areas. However, following up on the steps taken in Phase 1, the study now not only has within its scope the functional area, but Luxembourg the country itself, as well as broader scales of inquiry.

To propose an effective and potentially attractive transition towards zero carbon and (re)generative systems, the methodology will

require us to look at the country itself and its position and relationships in the world. This way, the proposal and analysis will not only identify isolated narratives, but rather tease out more comprehensive solutions, actions, and metrics which are comparable and applicable to other scales.

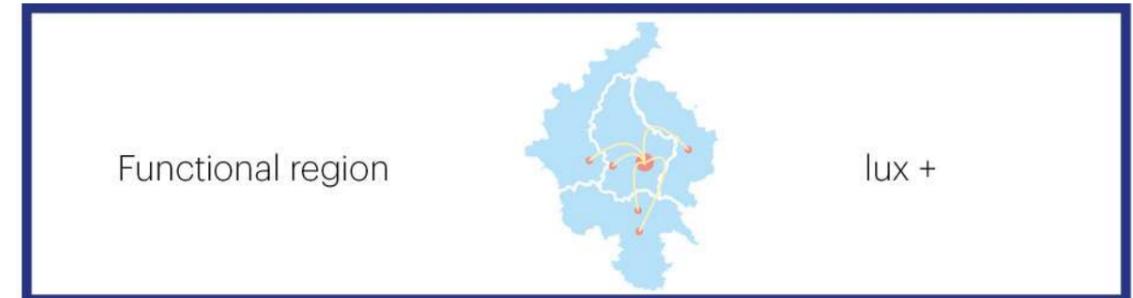
As Luxembourg transitions to zero carbon, and builds resilient, regenerative systems within its own sphere of influence, it can then begin to export this approach, enhancing the world's (re)generative systems, via the larger systems the region is connected to.



Luxembourg



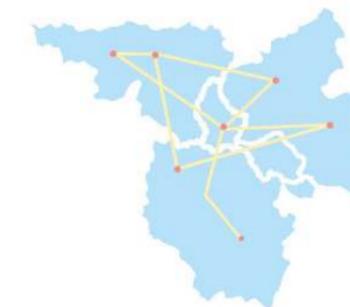
Lux



Functional region

lux +

Greater Region



lux ++

Europe



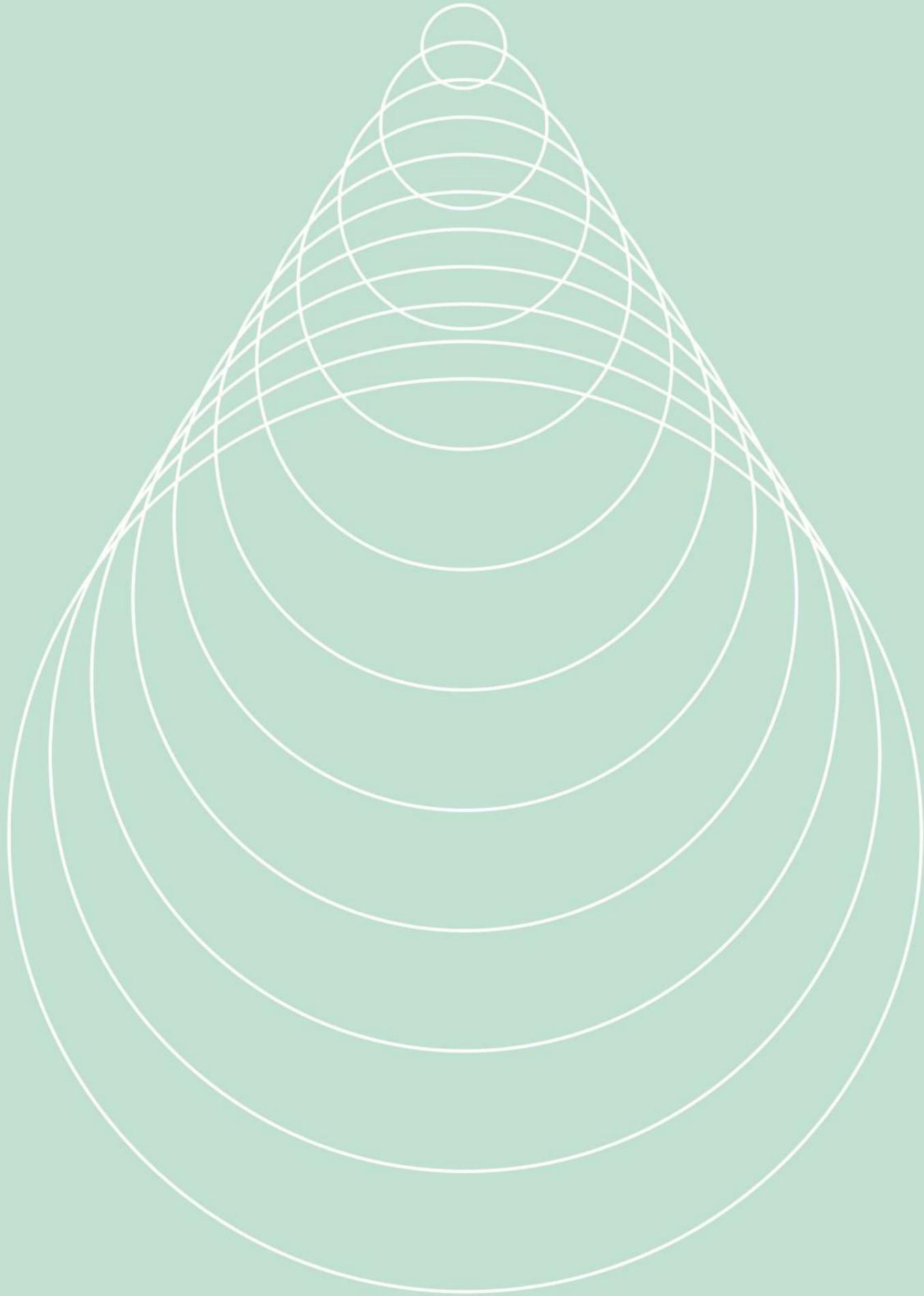
lux ++++

World



lux ++++++

Analysis



Lux + is...
Spatial planning review
Cross-border dependency
Growing and Shrinking region
Fragmented ecological
Conclusions

2

Lux + is...

A quadri-national employment range, and cross-border metropolitan area defines the Luxembourg Functional Area. While Luxembourg City is the heart of this system, other urban centres play an important role in local dynamics: Arlon (Belgium), Trier (Germany), Thionville, Longwy and Metz (France).

The complexity of this area exceeds multiple territories and languages. Each portion operates according to its own national administration as concerns the use of resources, the provision of services, and infrastructure.

While the Grand Duchy of Luxembourg is the world's richest country, the entire region lies under this influence, and by association has a high GDP. However, there are fundamental disparities between the regional parts that comprise the Lux+ whole. Germany produces a great deal of clean energy, but due to strong federal incentives, similar geographic regions in Luxembourgish territory lag behind Germany's clean energy production pace. In the West, Luxembourg is associated with the Belgian

territories of Arlon and Bastogne practicing sustainable agriculture more diligently than that on its own territory. While citizens enjoy free public transport within the Grand Duchy, and there is a TGV to Paris, promoting fast and convenient connection between the French capital and Luxembourg, much of this region relies on vehicular transport for its immediate commuting.

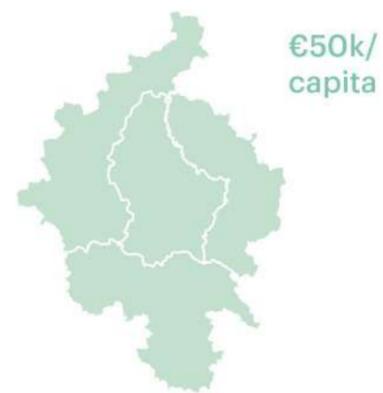
Can the system replicate good practice in more places and limit unsustainable practice in all regions?

Achieving social, economic, political, and environmental cohesion in the cross-border area is without a doubt the greatest obstacle to achieving a resilient, zero-carbon reality.

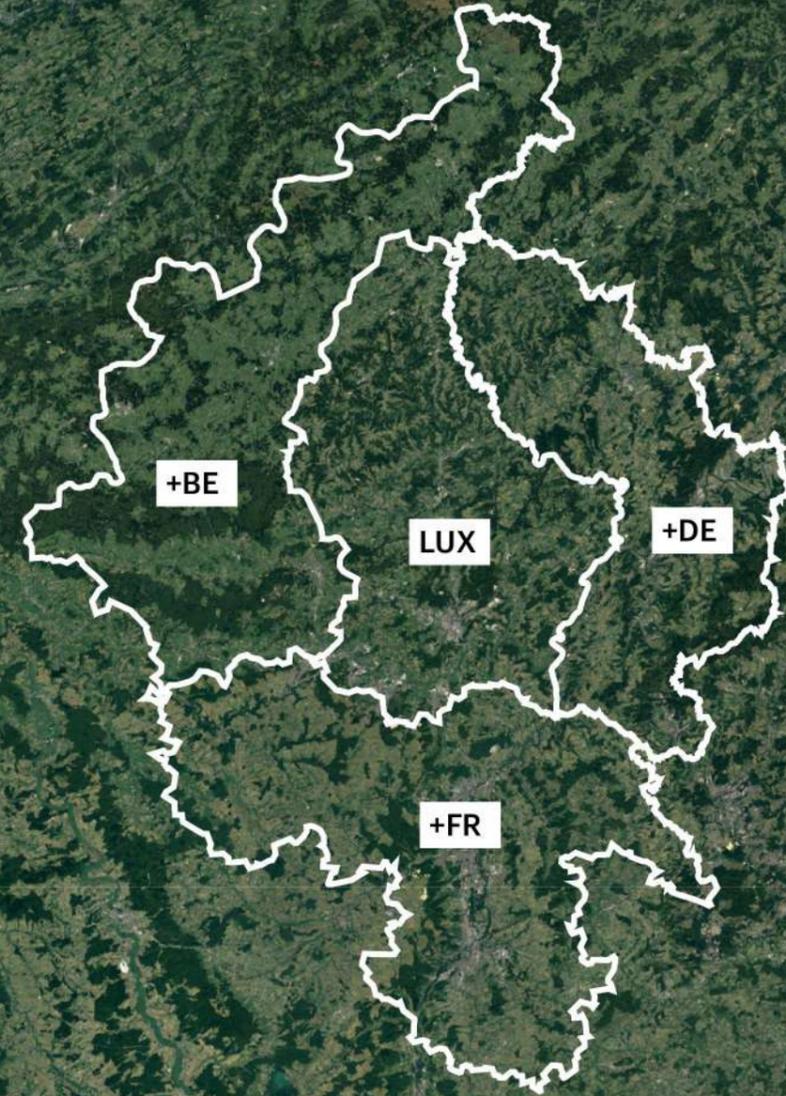
To understand the region and its unique challenges in more detail, we interview locals born and raised in different parts of this region as a means of understanding the how and the why of life in the functional area, and where opportunities for transformation lie.



Lux
620k people
Area = 2.582 km²
GDP/capita: 98k



Lux+
2 million people
Area = 11.638 km²
GDP/capita: 50k

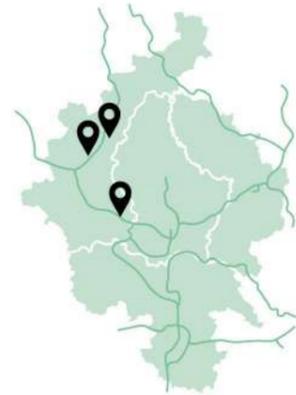


Lux+
2 million people
Area = 11.638 km²

Lux + is... Belgium: Wallonia



Maxime Cunin



I was born and raised in Belgium, in the Walloon municipality of Vaux-sur-Sûre, which is located in the province of Luxembourg. It is close to Bastogne, where World War II began its decline. The history of this place is also part of my history.

Not all the villages around this area are equipped with services suited to life on a daily basis, such as groceries, delivery services, schools, hospitals. For these, you must go to the next village or town, some 5 km, 10 km, or 15 km away.

Back in the day, farmers and local producers would provide for the basic needs locally, and the need to resource goods from outside the municipality was not so prominent. Today, we depend on larger urban centres. Some initiatives seek to address the local demand, in such ways as the fresh-food vending machine, brought about by a local farmer.

These good ideas are not always so visible or have the support to reach out to more people. Access to information is challenging, and there is not a great deal of experience exchange between the hyper-localized initiatives.

In terms of local production of clean energy, there is a compensation scheme, which encourages households to install photovoltaic panels. Under this scheme, you can deduct the solar electricity you feed into the grid from your electricity bill, in terms of both electricity purchased, and network usage costs. However, the municipality is phasing out this incentive, creating a concern about consumption costs amongst citizens.

Residents effectively collect and separate their own trash, in a very selective way. Homes have large waste bins, and you bring your waste to recycling centres once a week. This works really well.



Vaux-sur-Sûre



Bastogne

"Nature always forms the background of our lives. I can go from Bastogne to Wiltz by bike through a beautiful train track converted into a bike-way, surrounded by forest."

My village, Rosiere le Petit, is a place where kids run free, and nature is all around you. There are local green initiatives to enhance biodiversity and beauty, such as "Bocage" and "Villes Fleuris".

"The buses only pass every hour, and the network of bus lines is sparse. One must have a car."

From 12 years old, I started commuting to a secondary school in Bastogne by bus. There was one line that served many villages, which means the bus was always packed. At the age of 18, I went to a university away from this region. In Arlon I could pursue Agronomy, but I wanted a different career. Luxembourg was not so attractive because education would be in German, not French.

"Sharing a ride is a reality, as long commutes are common. Parking lots from large retailers function as a Park&Ride for shared mobility"

Sharing a portion of your commute is a way of saving fuel costs. My sister, for instance, meets other villagers in large parking lots and from there, they continue together. The idea of what is far away, or what is a reasonable distance is very car-based.

"You do not feel a hard border. You know you are in Luxembourg for the language, and the low prices for gas, cigarettes and booze."

Goods and wages are more attractive in Luxembourg, but living in Belgium is more affordable.



Lux + is... France: Lorraine



Romain Siness



I was born in Thionville, the second biggest city of the department of Moselle. It is about 20 km far from the Luxembourgish border.

I spent almost all my childhood in Thionville before moving away for my studies, in Nancy and Brussels. Growing up, I went to Luxembourg and Germany frequently, but as a kid, I was not conscious about the border condition. It became part of my reality as an adult and a worker.

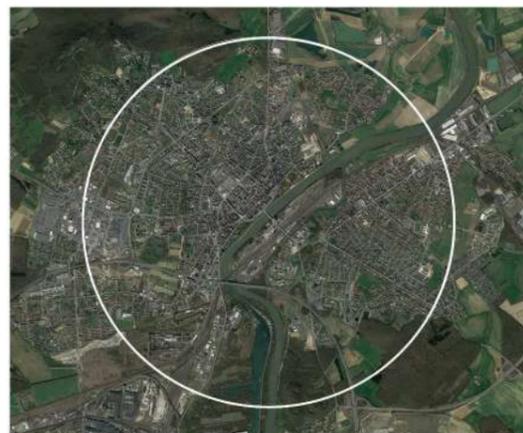
Living close to the border stimulates the "tank-tourism", when you go to Luxembourg for cheaper fuel, cigarettes and alcohol. For leisure, I would go hang-out here in France, but also, in Luxembourg and in Germany.

For two years I worked as a journalist for Les Frontaliers, in direct contact with the cross-border community and lifestyle. For almost all the jobs, the advantage of working in Luxembourg is the

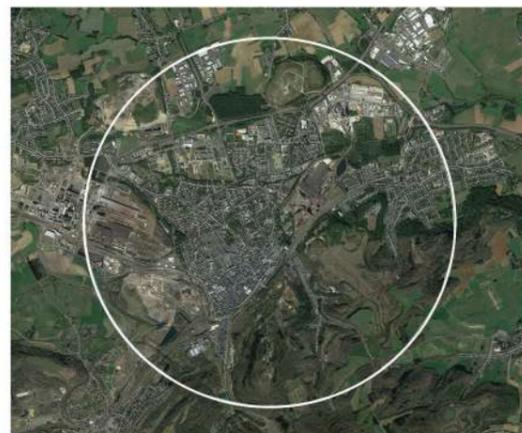
higher wage. In IT for example, a work field in explosion, the wages are very attractive. Through my work in Le Frontaliers, I have heard testimonies of internationals that do not feel welcome or a part of the Luxembourg community. However, Luxembourg as it is would not exist without cross-border workers.

Cross-border workers represent 45% of the active population in Luxembourg, from which half are French. The trend is that the share of cross-border workers continue to grow, and so does the tension about this issue between the countries.

Mobility is one the most serious topics in Luxembourg and in bordering countries. If you drive, there are heavy traffic jams. To take a train, you still need to drive to the train station, and the lines are not always reliable. You spend a lot of time in the commute, and your lifestyle becomes limited to commute-work-sleep.



Thionville



Esch-sur-Alzette, Luxembourg

"The cross-border lifestyle is exhausting. There is no convenient means of travel"

Living in Thionville and working in Luxembourg, I usually need about 35 minutes to travel to my workplace. In rush hour, if there are accidents or road maintenance, it can take up to 1h30. And I'm not talking about the highway. The A31 highway from France, is one of the busiest in France.



"Living in Thionville you can see the difference between the French, Belgian, German and Luxembourgish wages, real estate costs, mobility and taxes"

Living costs and real estate prices are higher the closer you get to Luxembourg, even comparing small villages by the border to Thionville or Metz.



"At after-work parties in Luxembourg, most people I would meet in a bar would be career driven, and interested in a lifestyle of apparent success."

The opportunities in Luxembourg make society competitive, and dynamic, similar to a "Parisian" lifestyle. The atmosphere is very cosmopolitan. You can hear English, French, Turkish, Portuguese, and Russian, all at the same restaurant.



"Personally, what I enjoy the most are the simple things in life."

I quit the commuter life because I do not wish to spend all my personal time on a rush, focused on making more money. I appreciate the simple things, and value being mobile and flexible as a journalist. I am now again living in Thionville close to my family, but I'm technically based in Paris. This was made possible because of remote working, due to the C19 pandemic.



Lux + is... Germany: Rhineland and Saar-land



Franziska Wollscheid



I was born in Rhineland, in a small village called Damflos, which is close by to Trier. Part of my family is from Saar-land I studied and worked in Trier and in Luxembourg. We call this region the SaarLorLux area, comprising Saar-land, Lorraine and Luxembourg.

As a kid, my school was 5km away from my village, a route that I would travel by bus. The villages are connected to larger town through a bus system scheduled according to school hours. For my bachelors degree, I chose to remain in proximity to my family, so I enrolled in Hochschule Trier.

In this region, life is very car-based. There are bike-lanes, and e-bike systems, but the elevation difference is a challenge for active mobility. Damflos is at an elevation of almost 600m, whereas Trier is at 130m above sea level. The bike trip up-hill could effectively take almost 5 hours.

There could be a bike connection from Trier to Luxembourg following the course of the Moselle river. Along the river, the elevation changes are not so expressive, which could be an opportunity for active mobility modes along an attractive, natural setting.

Young people move to Trier and Luxembourg seeking opportunities, but the aesthetics, life quality and affordability of the small villages cannot be found in such metropolitan settings. The seniors that stay in the small villages cannot find such easy access to care and daily goods, but they are less mobile to do large trips towards urban centres. That is an issue in this area.

Living here is very nice, and it would be even better if there were more services activities and amenities close by, and less dependency on car.



Danflos



Trier

"It is very nice to have a home in a secluded place, surrounded by nature, but at the same time 30min away from a metropolitan city with opportunities: Trier"

Having a half an hour walk in the forest or fields is part of normal, daily life. You realize this when you move to a larger city, and miss the contact with nature.



"In the SaarLorLux area, you need to have a car."

When you turn 17 years old, you want to have a car and show it off, it represents you independence and freedom. You attend higher education in larger cities, close to your village.



" There is an imbalance of where each segment of the population live."

Young people need the opportunities of big cities, but cannot afford or enjoy the aesthetics and life-quality there. Older people stay in the villages, far from healthcare centres when they are the least mobile.



"The concentration of activities in Trier and Luxembourg prevents other villages from having regional relevance."

Remerschen, Shengen, for example, has a nice setting for leisure and connectivity to 3 countries, but right now it is only a place that you drive-through. This region needs a greater mix of programs and amenities such as art centres, parks, and other stimulus to retain young people.



@Courtesy from Franziska Wollscheid

Lux + is... Luxembourg



Jo Schumacher



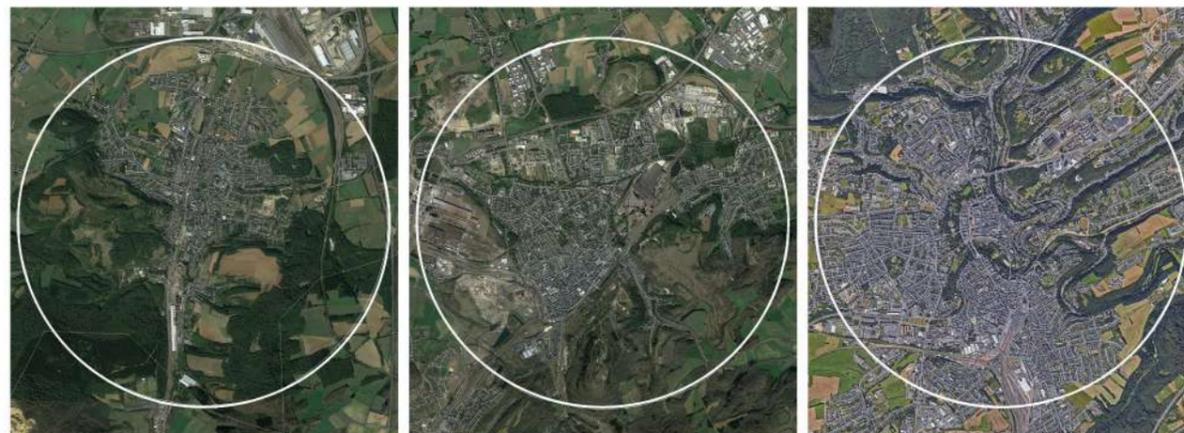
I was born and raised in Dudelange, the forth-most populous commune in Luxembourg. I studied in Esch (Esch-sur-Alzette), which is 45 minutes by bus, to the West. The transport system is free and well-served well. These cities are along the southern border of Luxembourg, two minutes away from France, so daily traffic jams were part of my reality, especially from 4-6pm, when drivers avoiding A31 use alternative routes on their home commutes.

The cross-border influx influences hostility from locals towards international commuters. Part of the community have a nationalistic mindset, and believe the international workers take a toll on the local resources such as infrastructure and employment. Another part of the community sees a great advantage in having these workers contributing to revenue within Luxembourg, without demanding much from the national public services of health, housing, and more.

At home, with family and friends, we speak Luxembourgish, but the school system is in German, the regulations in French, and at my work I use English.

I completed my bachelors degree in Luxembourg City, and my masters in the Netherlands. This is not very common: many students seek out international experiences in the immediately neighbouring countries, for instance, in Trier. The Luxembourgish can be very risk-adverse.

There are two artificial lakes close by where we go to enjoy nature on weekend get-aways. One in Esch-sur-Sure and Remerschen, Shengen. In Remerschen there were once metal industries around the area, but not anymore. So this lake is now clean and used for environmental and leisure purposes.



Dudelange

Esch-sur-Alzette

Luxembourg

“There is a misconception about the importance of agribusiness in Luxembourg”

The agriculture industry in Luxembourg wields considerable political power, and has its own Ministry of Agriculture. This gives an impression that local villages and communities depend on this sector, but it actually contributes very little to the GDP.



“As a young student or professional, you always stay with you parents, because you cannot afford a place on your own.”

I did my bachelors degree in Luxembourg city, and later embraced the challenge of doing my masters in the Netherlands. This is not very common as many students seek out nearby international experiences, for instance in Trier.



“There are incentives to reduce car use, mostly through public transportation offer, but bike-lanes are not attractive.”

Luxembourg is offering public transportation for free, building a domestic line independent from cross-border commuting and expanding the TGV. However, there are no effective measures to enhance transit connection to Belgium and Germany, nor to make biking more attractive.

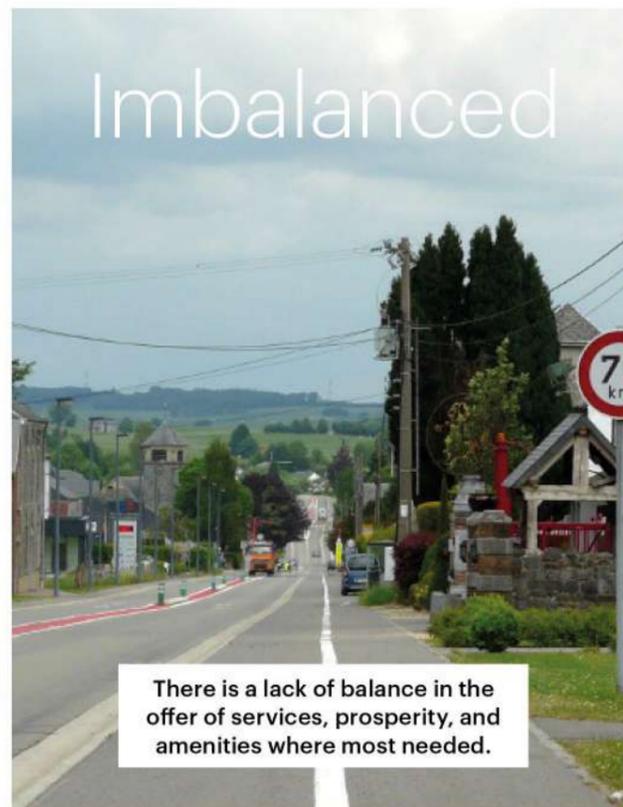
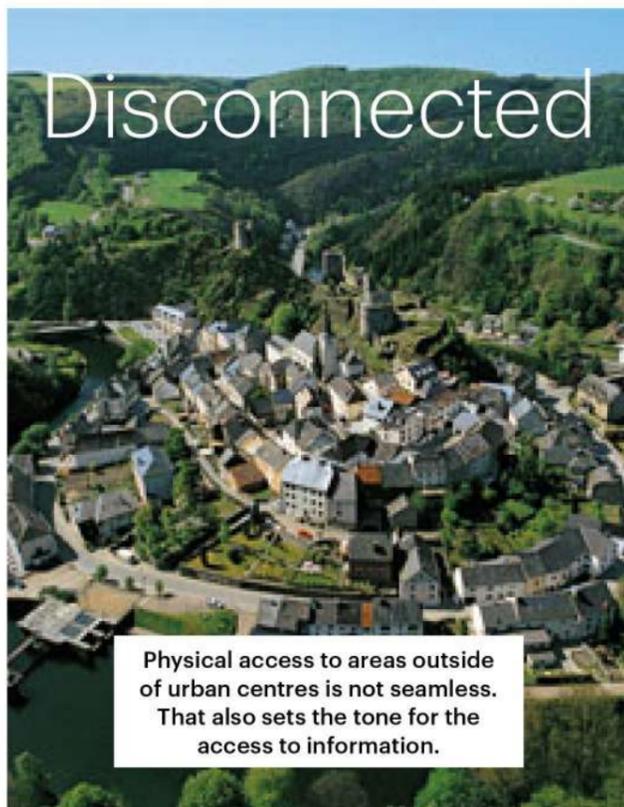
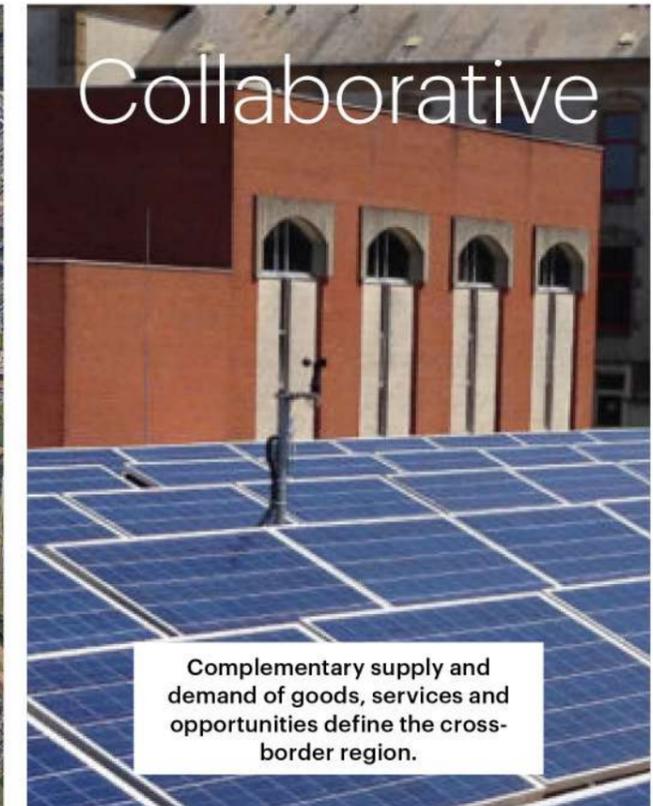
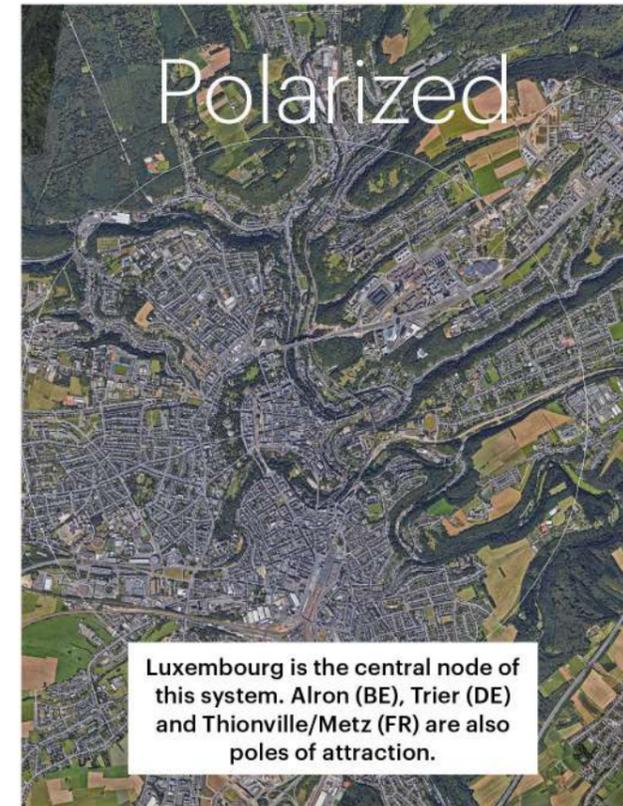
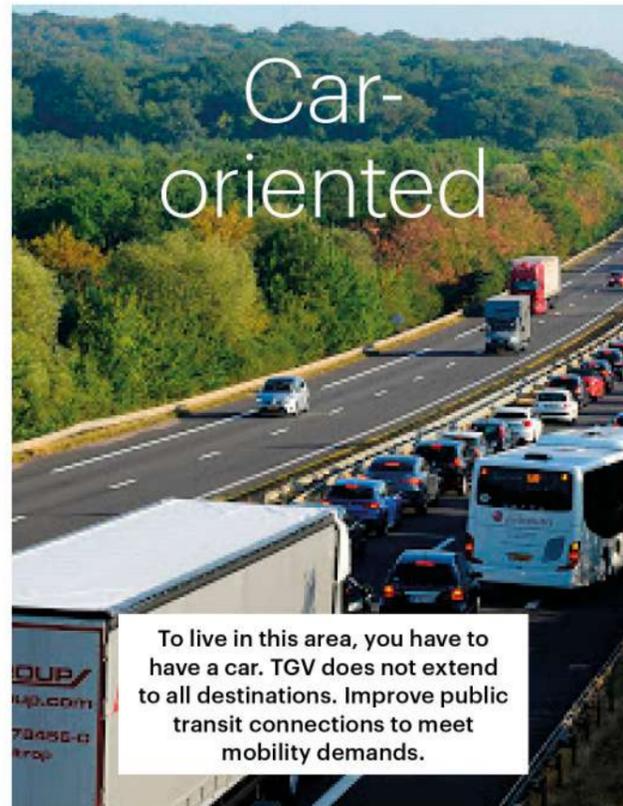
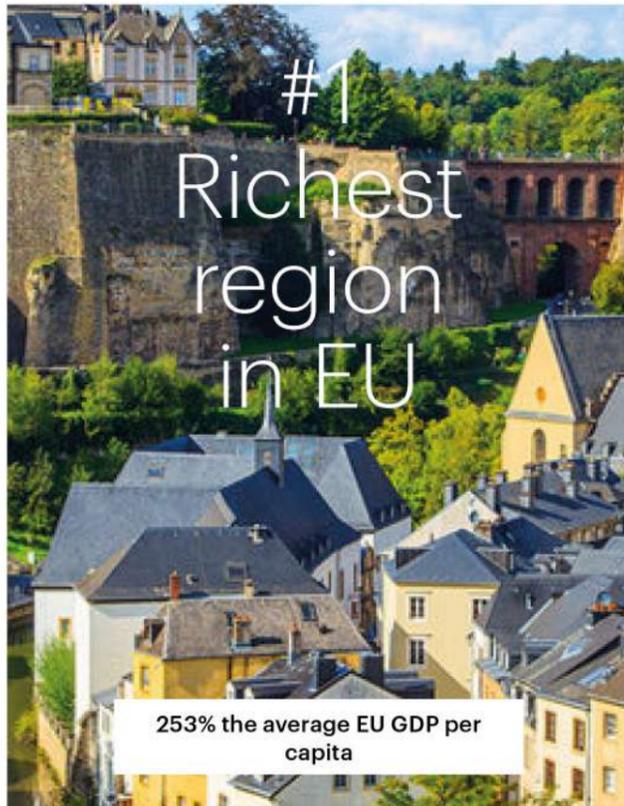


“There is a duality between being aware of the need for clean energy and being able to afford individual actions”

There is awareness about the need for energy transition. However, the older population that has the means to invest in individual upgrades, and local production of clean energy is not very engaged in taking action. The young population sees value in making such investments, but do not have enough funding for effective change.



Lux is...



Sectorial plan reflection

From the recent best practices in local governance, the Plan Sectorial published in March 2021, for the Grand Duchy of Luxembourg, is worth taking in consideration. It introduces 4 Sectorial Plans concerning Housing, Economic Activity Zones, Transport and Landscape.

The plans aim to improve life quality and protect the environment. The plans are drawn for the the Grand Duchy, but nonetheless reflect regional pressures relevant to the Functional Area: rebalancing Urban Growth.

Landscape sectorial plan

- Protect landscapes by preserving certain spaces from additional fragmentation and sprawl
- keeping spaces under urban pressure between localities free from construction
- Allow the fulfillment of the landscape functions (ecological, recreational, agricultural and forestry production and tourism functions)

Transport sector plan

- Reserving areas and corridors to be kept free of any construction intended to accommodate transport infrastructure projects

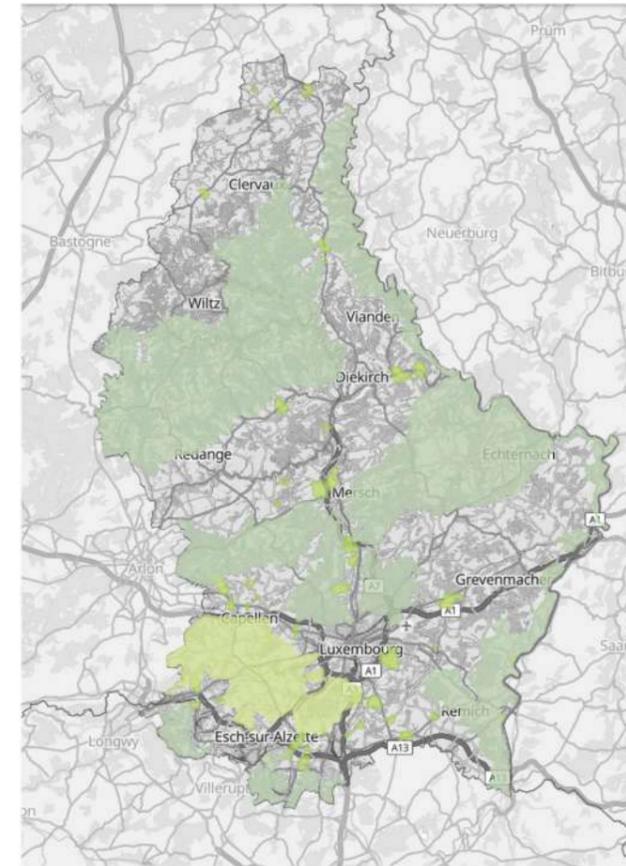
Housing sector plan

- Define priority housing zones intended for the creation of housing
- Reserving surfaces to allocate population growth in the most appropriate places of the national territory
- Promote more affordable housing: 30% of gross building area.

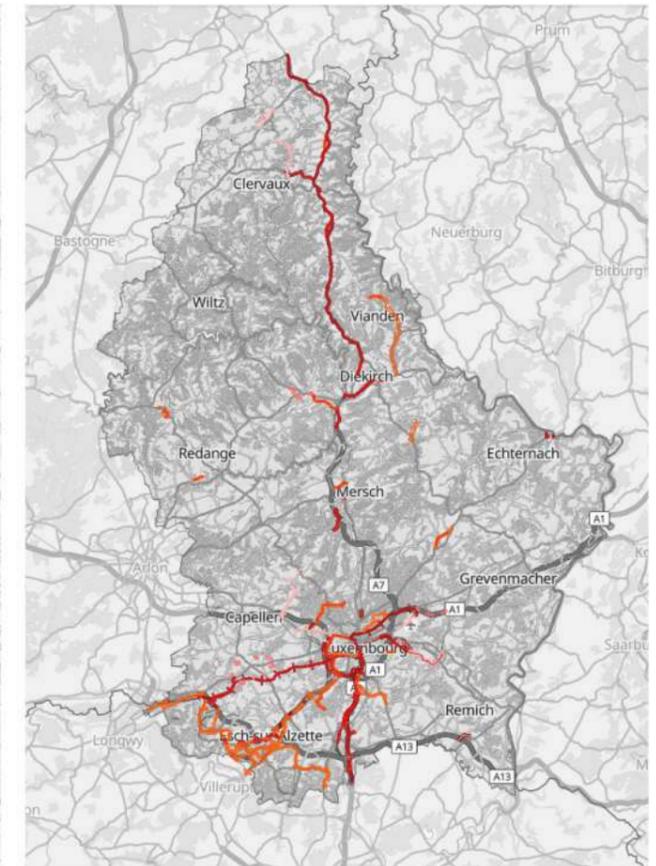
Economic activity zones plan

- Reserve areas for primarily craft and industrial activities
- Balance development of the territory subject to urban sprawl
- Encouraging inter-municipal strategies for the priority implementation of regional economic activity zones.

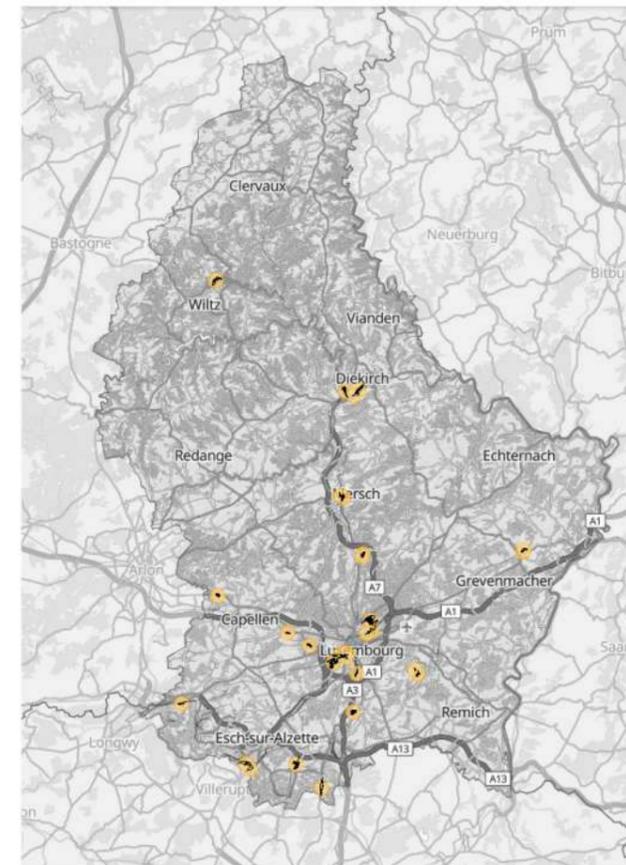
These principles can be taken as a framework of how to deal with the Urban Growth also in the Funtioal Area. As borad guidelines, they need to be specifically adapted to each particular region. For that, we investigate the key indicators to understand Urban Growth and how it can be managed in the Functional area region.



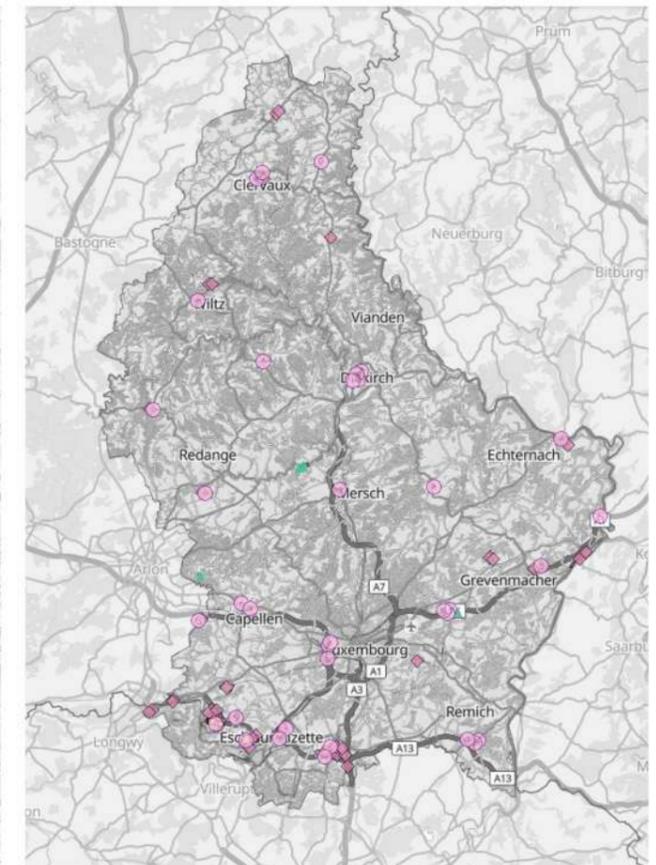
Landscapes sectorial plan



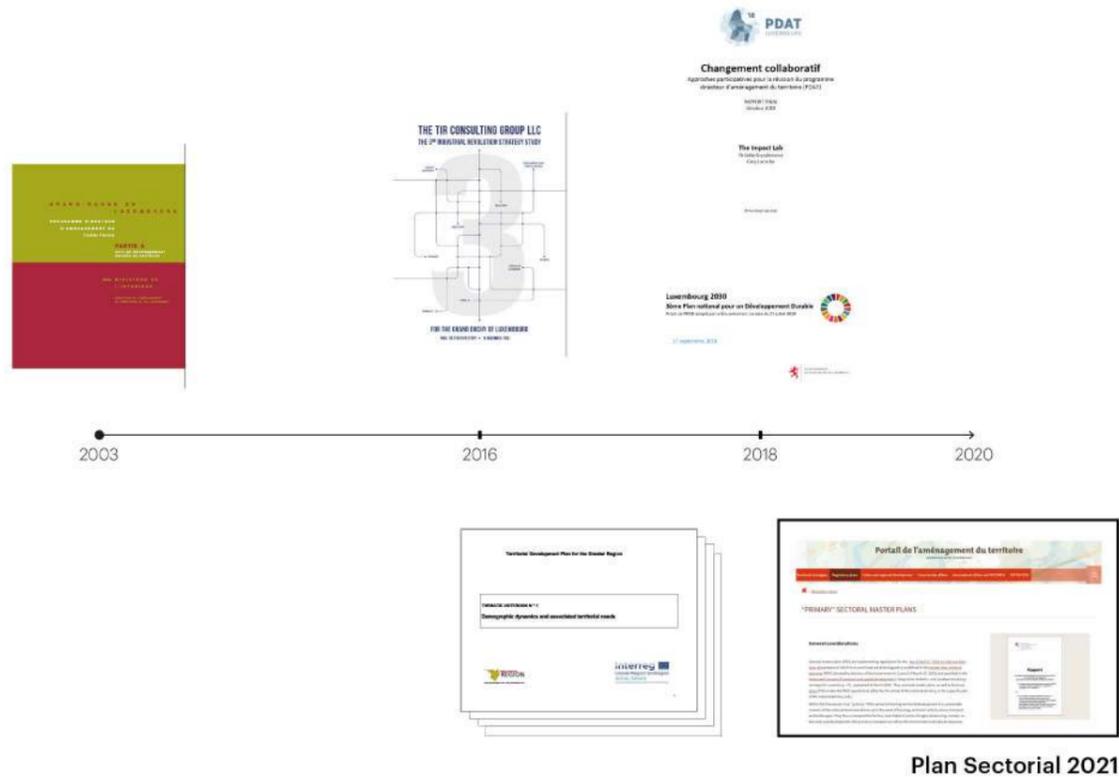
Transportation sectorial plan



Housing sectorial plan



Economic activity zones sectorial plan

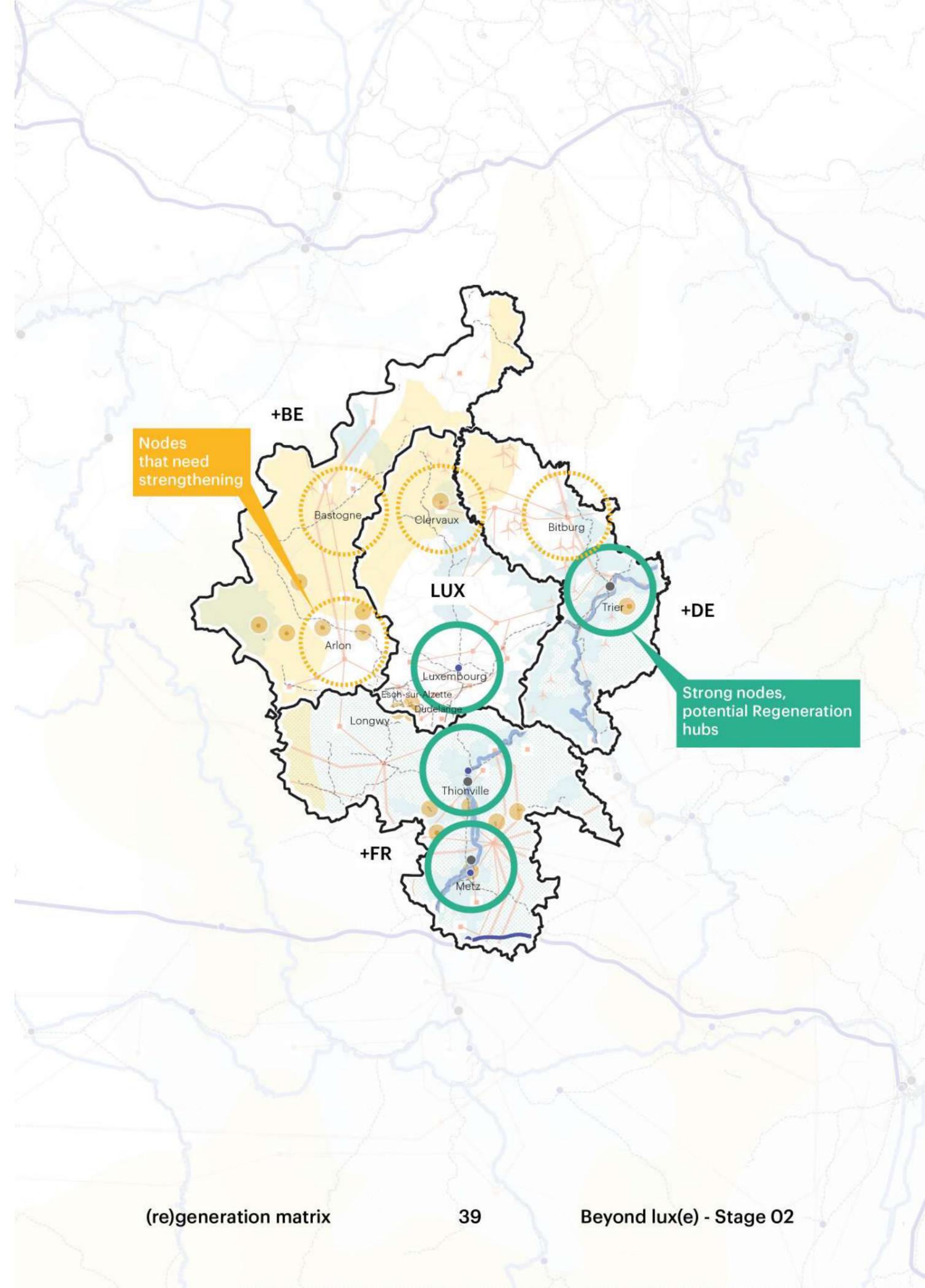
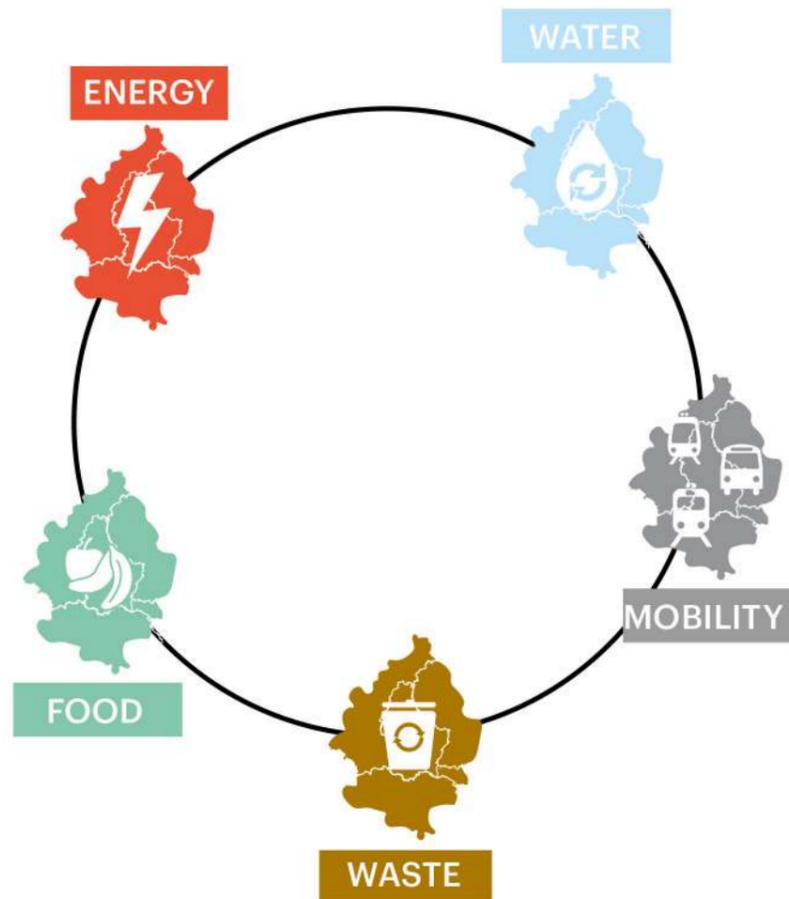


Plan Sectorial 2021

Cross-border dependency

Through the mobility of goods and people, the cross-border condition in the Luxembourg Functional Area is most visible. Indeed, this movement is a large part of the challenges it faces in the transition to resilience. This has tangible consequences for everyday life: traffic jams, air pollution, noise, stress, food waste, a predatory use of public space, and capital dedicated to the car.

However, the cross-border dependency on the Luxembourg region presents other measurable challenges. These challenges exist in multiple focus areas and are as relevant to the net zero transition as mobility is. Investigation of their implications in the transition will inform our actions and place them in the territory, in order to pursue potential synergies.



Food

In the Functional Area, there is a divide between the north and the south in terms of the use of agricultural practices. In Belgian and Luxembourgish area, pasture and animal farms dominate, whereas in the Functional Area's tracts in France and Germany along the Moselle river, there is a wide range of agricultural uses.

It is evident that production is predominantly focused in business, not local supply. In the case of the Grand Duchy of Luxembourg, it produces more than it consumes in meat, while importing almost all of its fruits and vegetables.

This requires movement of goods, and infrastructure in support. Although there are trimodal hubs that centralize the transport of goods by truck rail or boat, areas that receive service does not equally cover the whole territory of the Functional Area. Belgian towns on the

northwest side of Luxembourg are especially far from the freight network, making access to goods less efficient than in places around Thionville in France, or Trier in Germany.

The application of sustainable agricultural practices in the Functional Area remains voluntary. Despite not being a legal requirement, organic farming is an important factor in improving the environmental conditions of agricultural areas, in terms of biodiversity, water quality, soil protection, and landscapes cohesion.

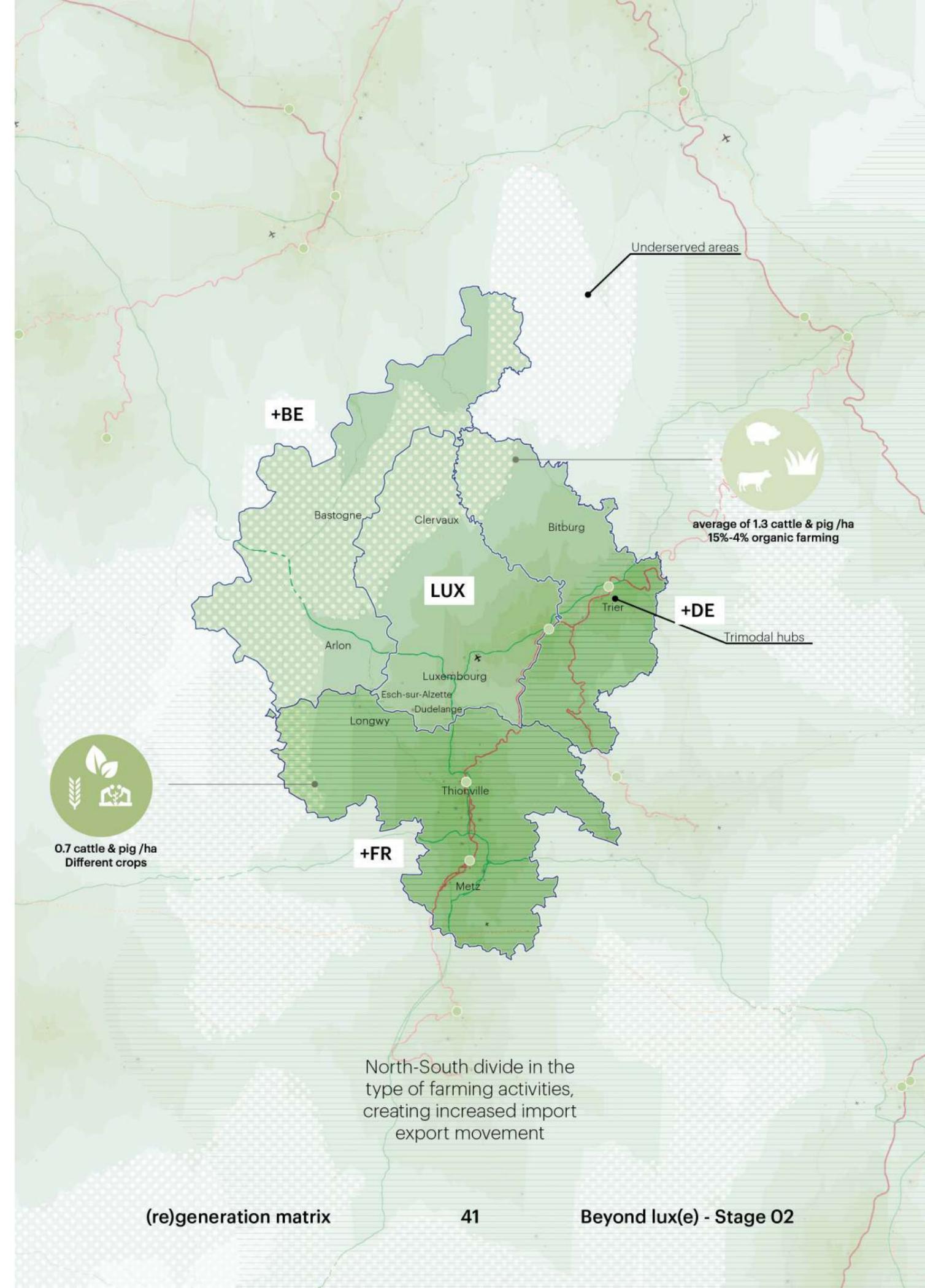
Animal breeding, monoculture and the use of agrotoxics are practices known for taking a toll in the environment. For a resilient and decarbonized region, these practices must subside. Consumer demand will influence the trend toward environmentally-friendly agricultural production and transport of goods.

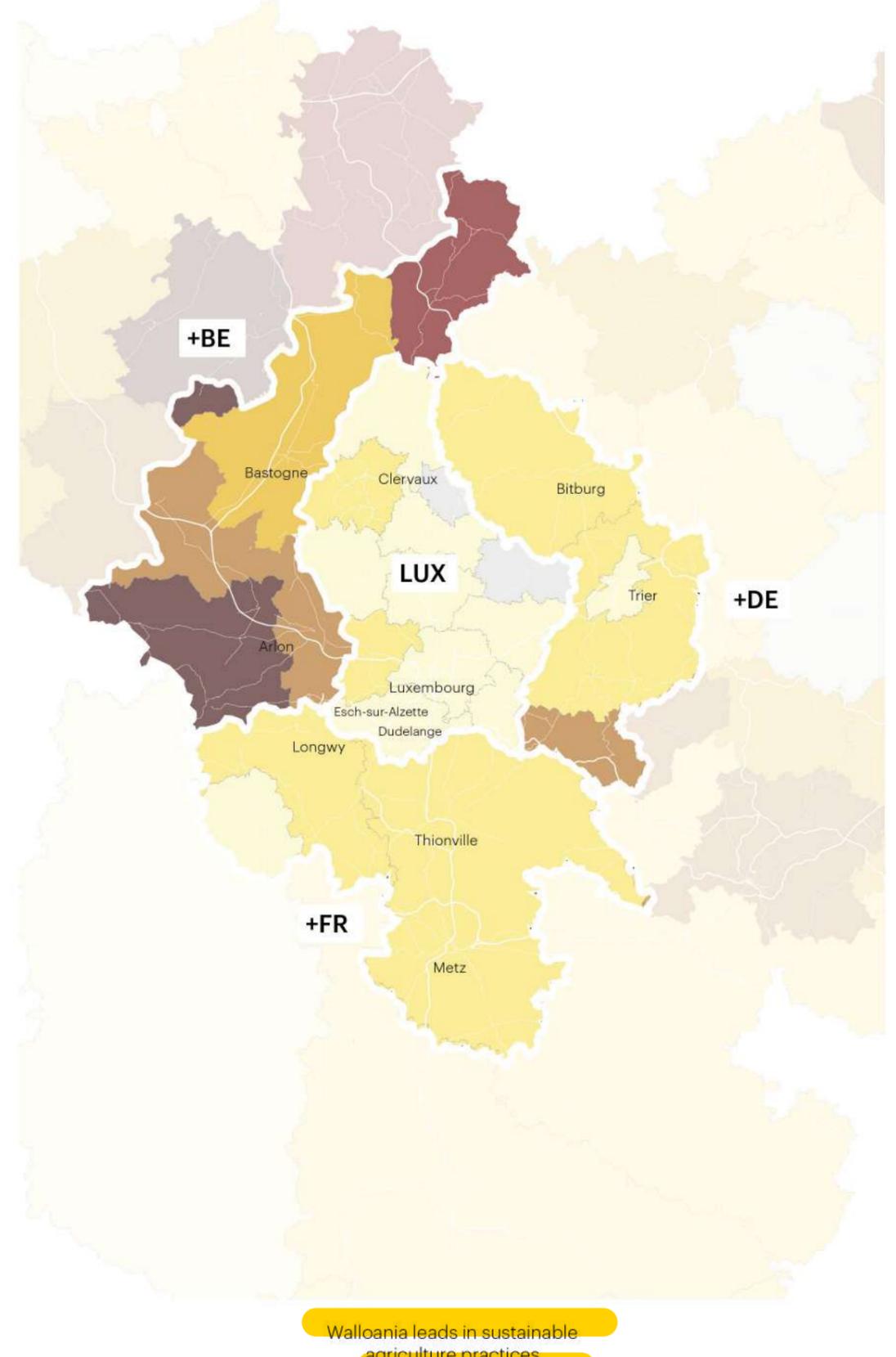
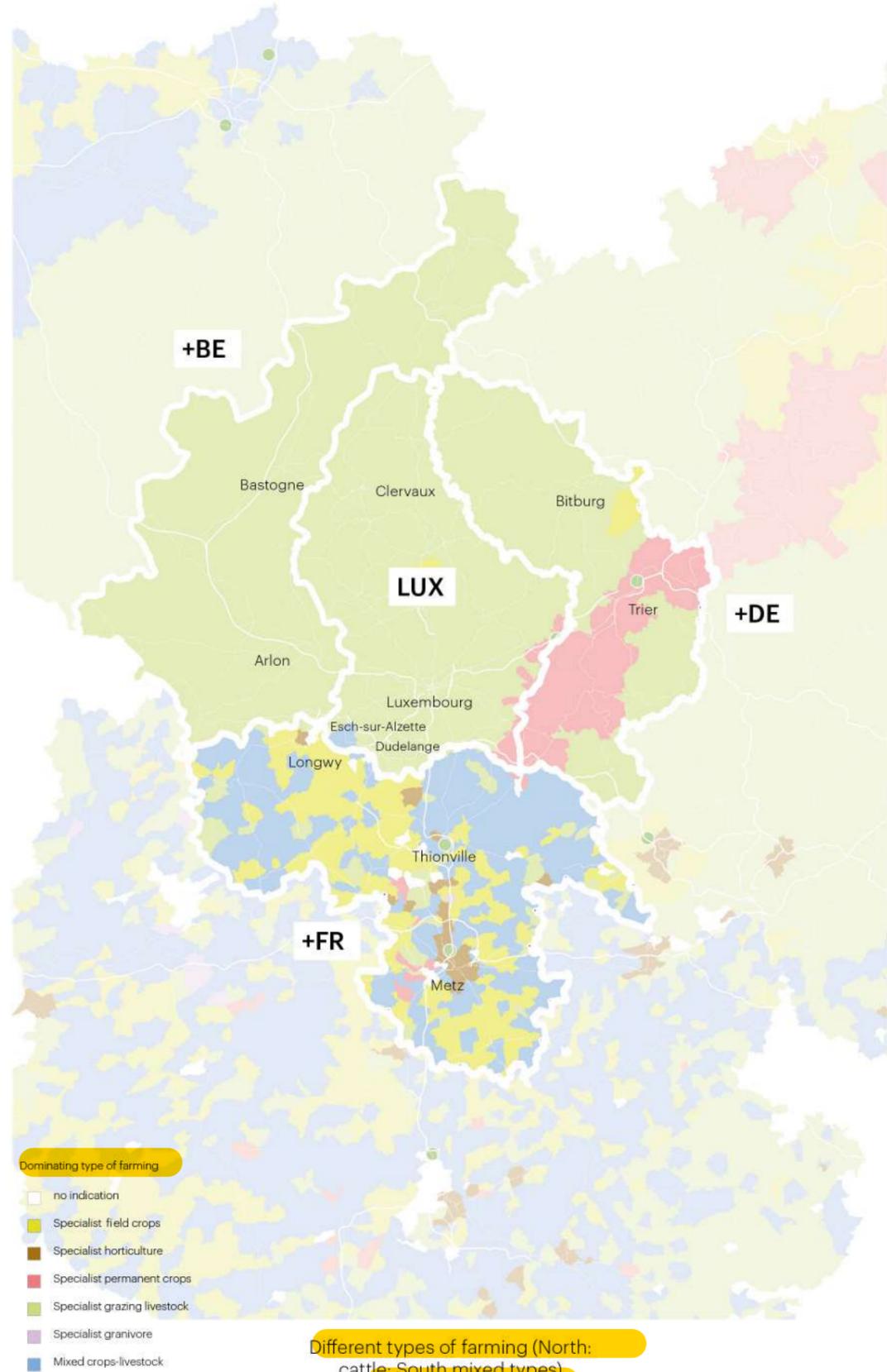


Farms in Luxembourg



Vinards around Trier (Courtesy from Franziska Wollscheid)





Energy

Players in the cross-border context are currently discussing the energy transition, as the whole of the European Union aims to reduce greenhouse gas emissions by 80% to 95%, compared to 1990 levels, by 2050.

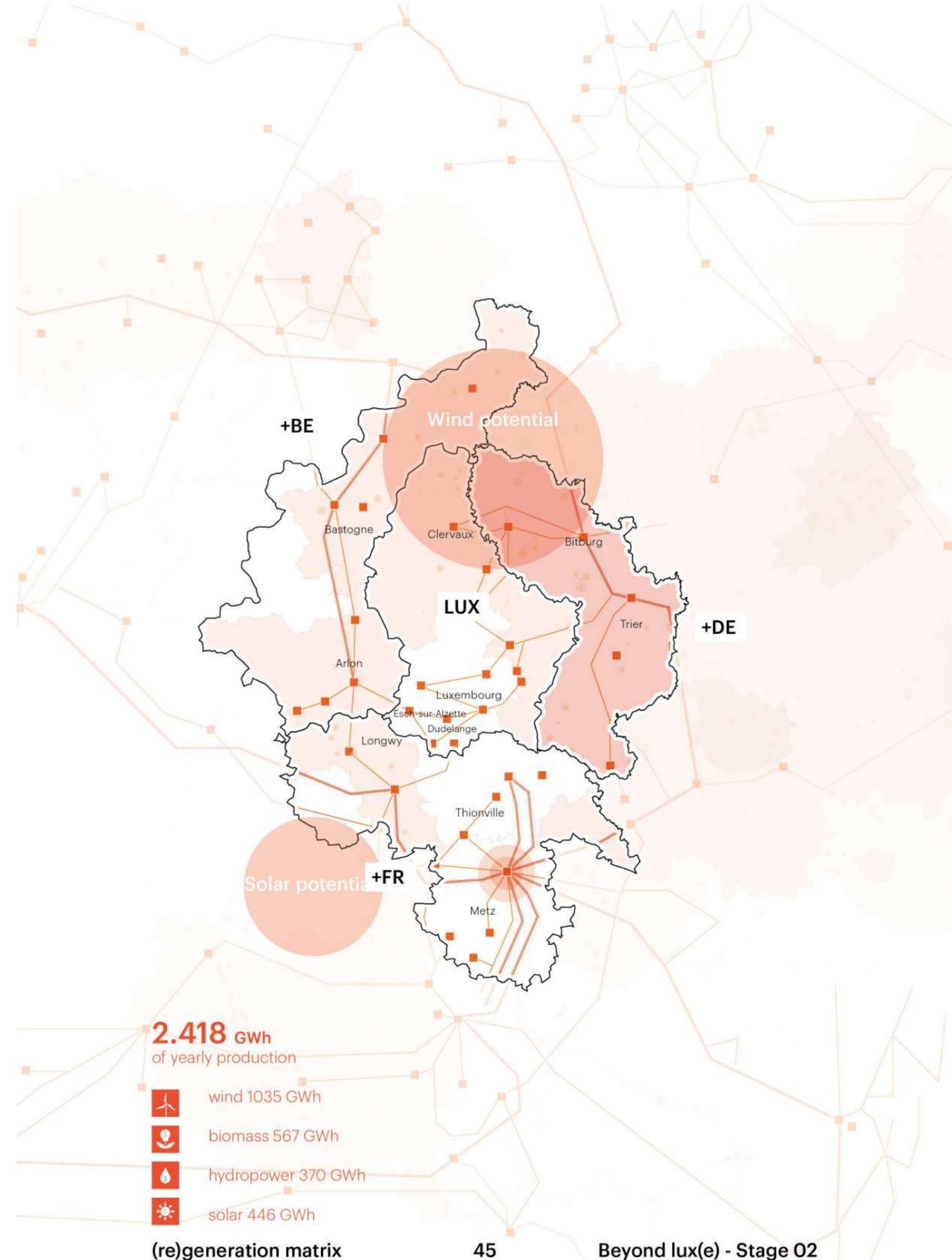
The challenge specific to the territory within the Functional Area is the fact that fossil fuel is relatively inexpensive.

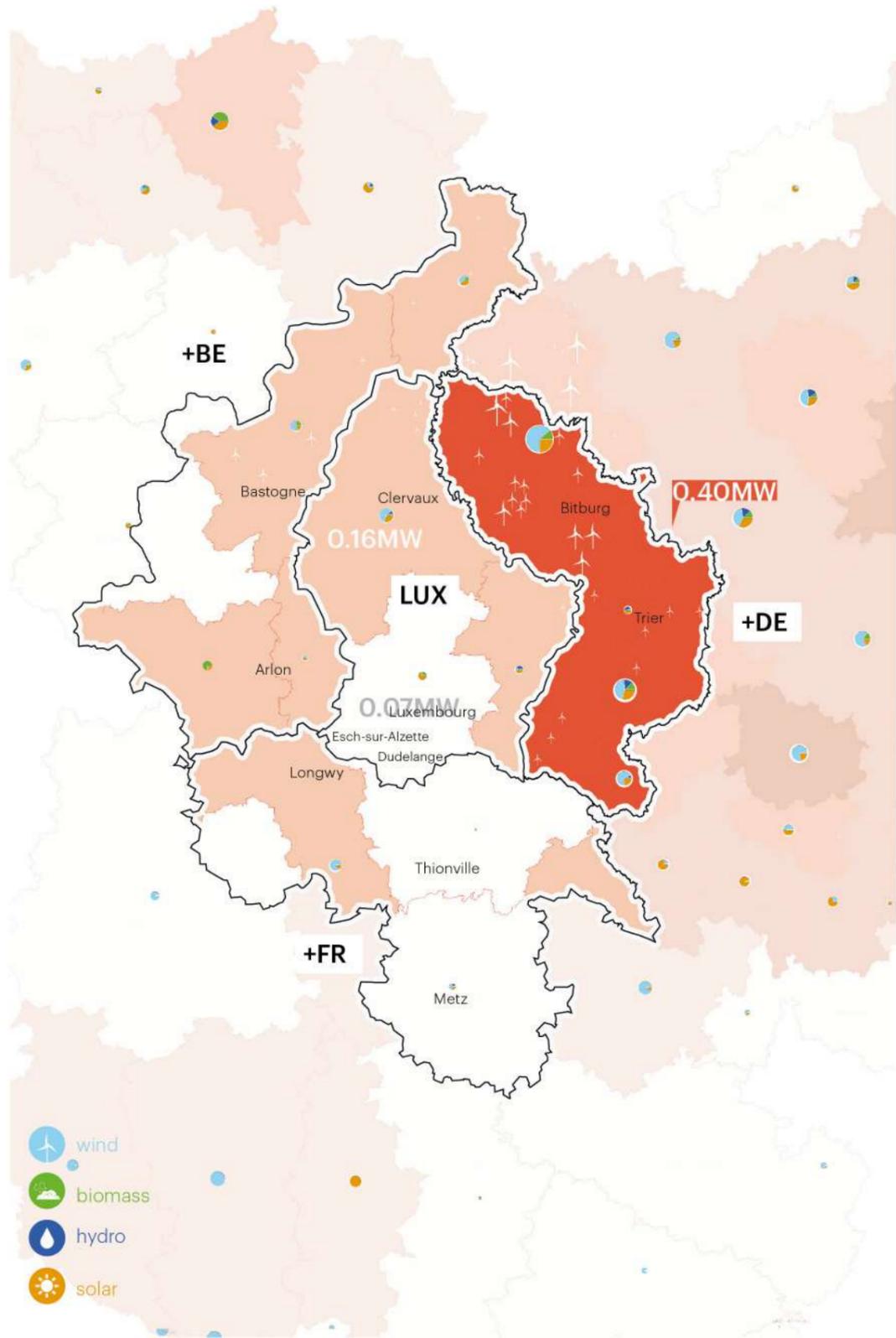
To be accepted, the Functional Area must roll out decarbonization strategically in the different parts of this territory. The cities that are mainly residential and old buildings, such as historic towns like Bastogne, present a clear challenge to reducing energy consumption by increasing building efficiency. This is because consumption relies heavily on individual initiatives that must match awareness and willingness to adapt, with

the funds and the disposition in investing in building upgrades. Restrictions on how to retrofit cultural heritage buildings presents a challenge in places such as Luxembourg's city centre.

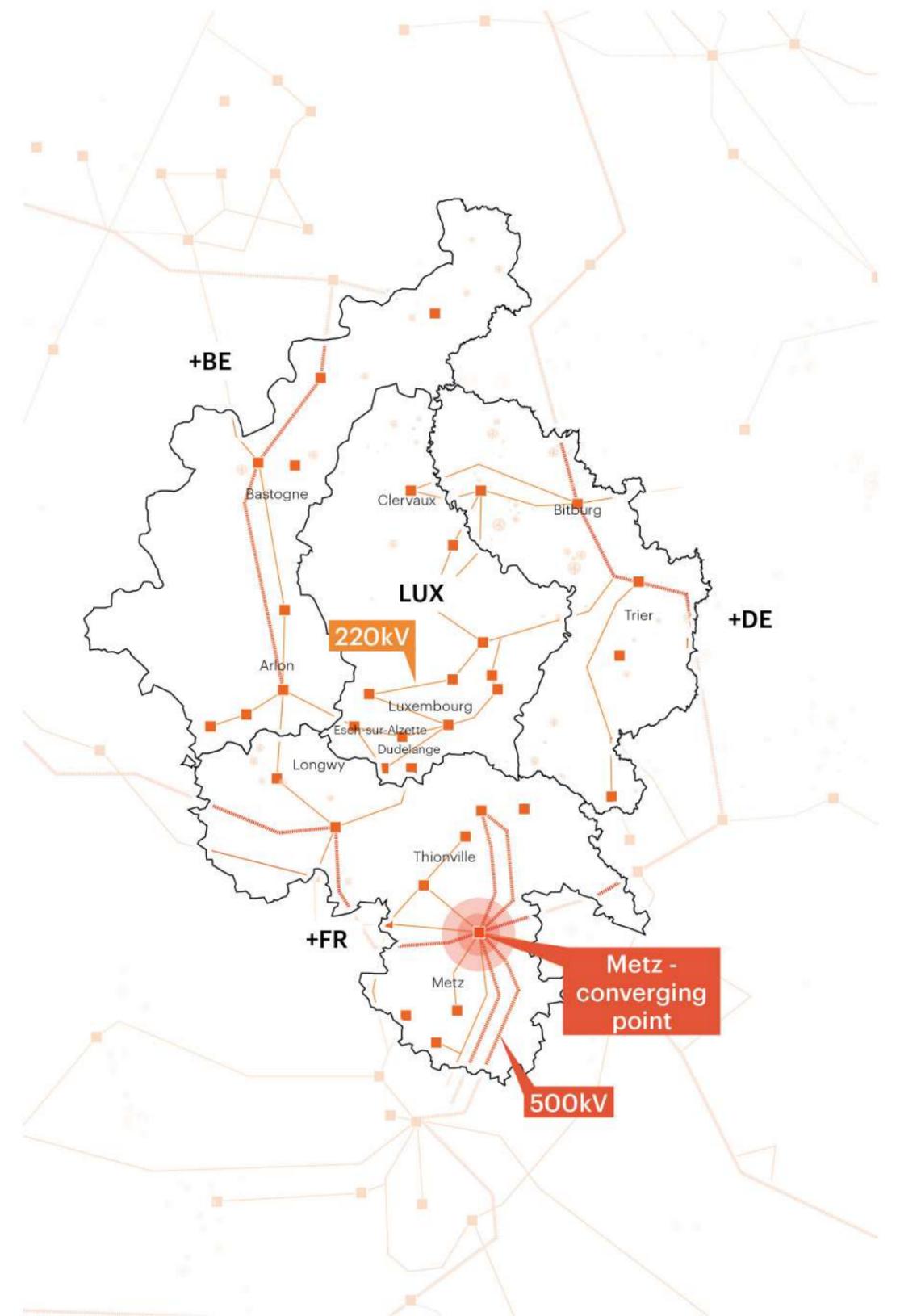
Despite the fact that strong governmental incentives incite effective change, in the case of Bastogne, the public incentives for residents to produce clean energy face removal or limitations in 2021. This is a significant retreat in steps toward the energy transition.

On the other hand, towns in and around the north of Trier have increased wind power and photovoltaic production, in order to achieve 100% clean energy by 2030. This is a result of Germany's strong national policies.





Clean Energy potential and Types of Clean Energy production



Transmission lines

Water

As a natural resource, bodies of water extend beyond administrative boundaries. It is not possible to draw a direct causal relationship between man-made alterations in the natural environment and their impact beyond country boundaries, but it is possible to identify correlations between activities upstream and their consequences down the course of a river.

High Soil Sealing rates in areas such as Luxembourg City, Esch-sur-Alzette, and Dudelange, can contribute to floods along the Moselle River and beyond the Grand Duchy: in France, and Germany.

On the other hand, it is also possible to identify good practices and environmental approaches with positive returns within the region that chooses to adopt them. In Wallonia, the farms

near Bastogne and Arlon embrace organic agriculture more diligently than the neighbouring farms in Luxembourg. Consequently, the quality of surface and ground water is much better on the Belgium side of the border.

The Greater Region of Luxembourg has begun to implement governance tools that structure participatory water management involving multiple actors (political, administrative, economic, associative or scientific) of the same basin or hydrographic sub-basin.

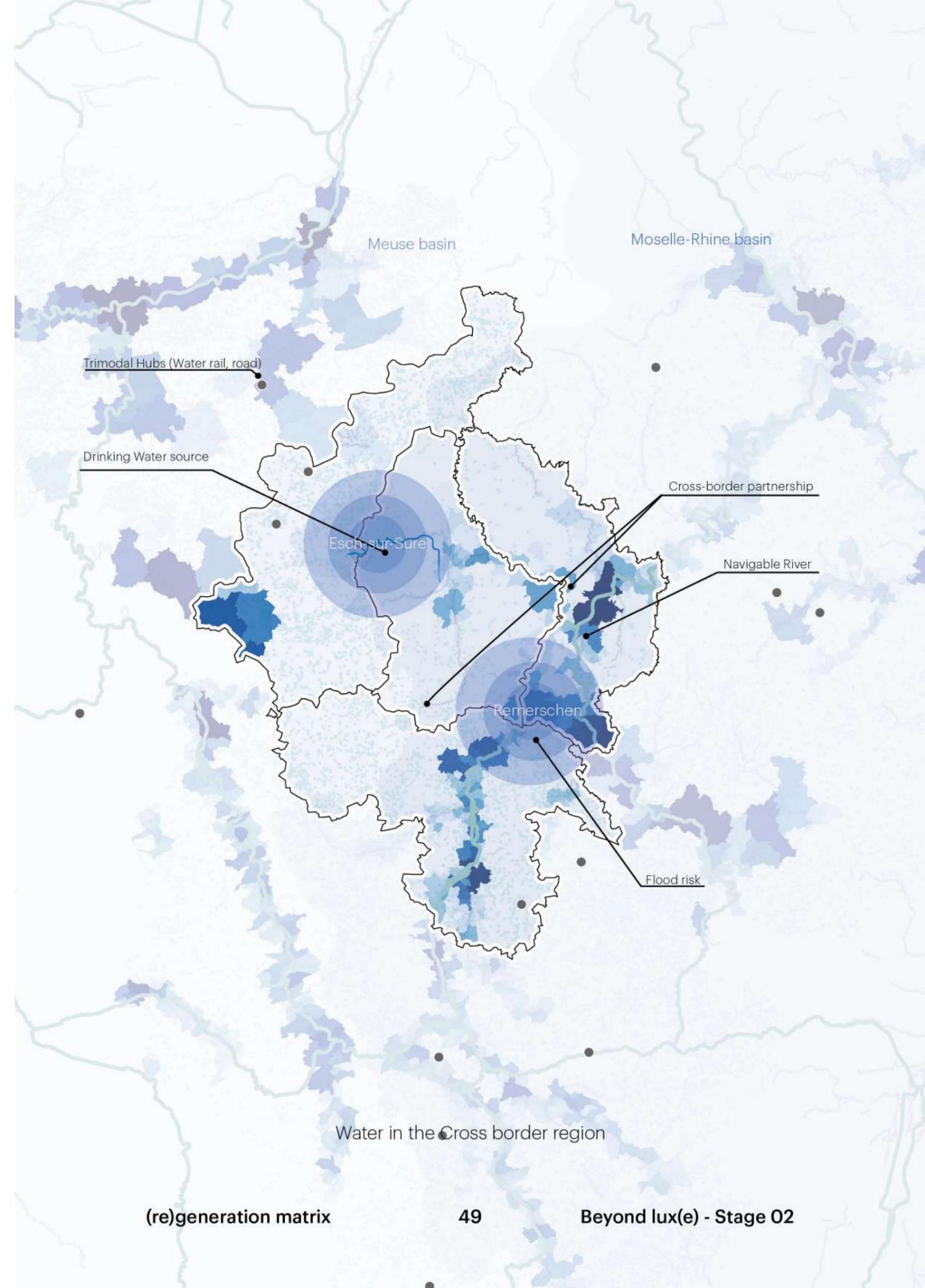
For a zero-carbon and resilient future, the Functional Area must achieve cohesion across the territory according to how areas preserve water resources manage risks. Limiting pollution and using storm water run-off helps to preserve water resources for a resilient future.

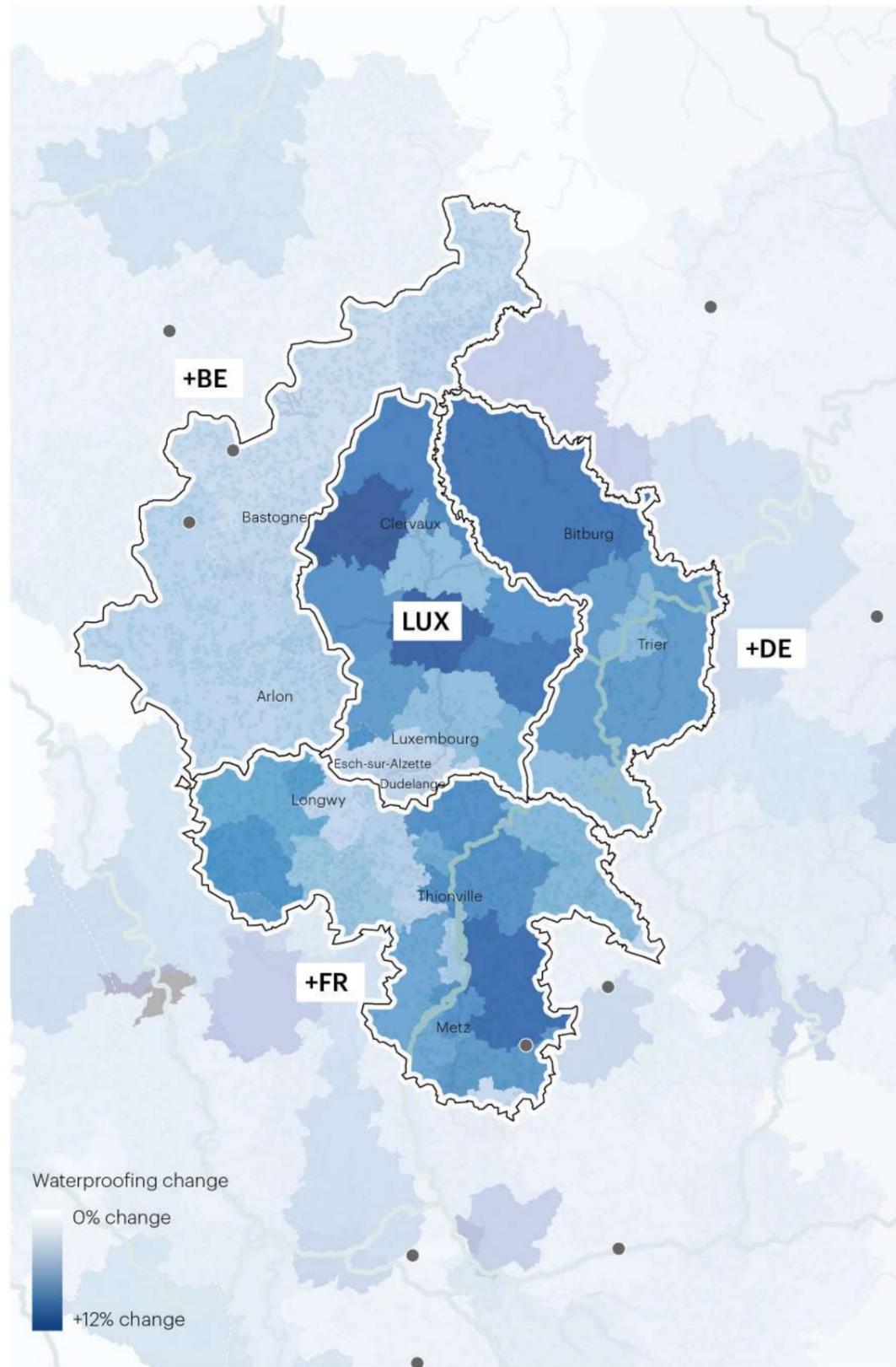


Esch-sur-Sure

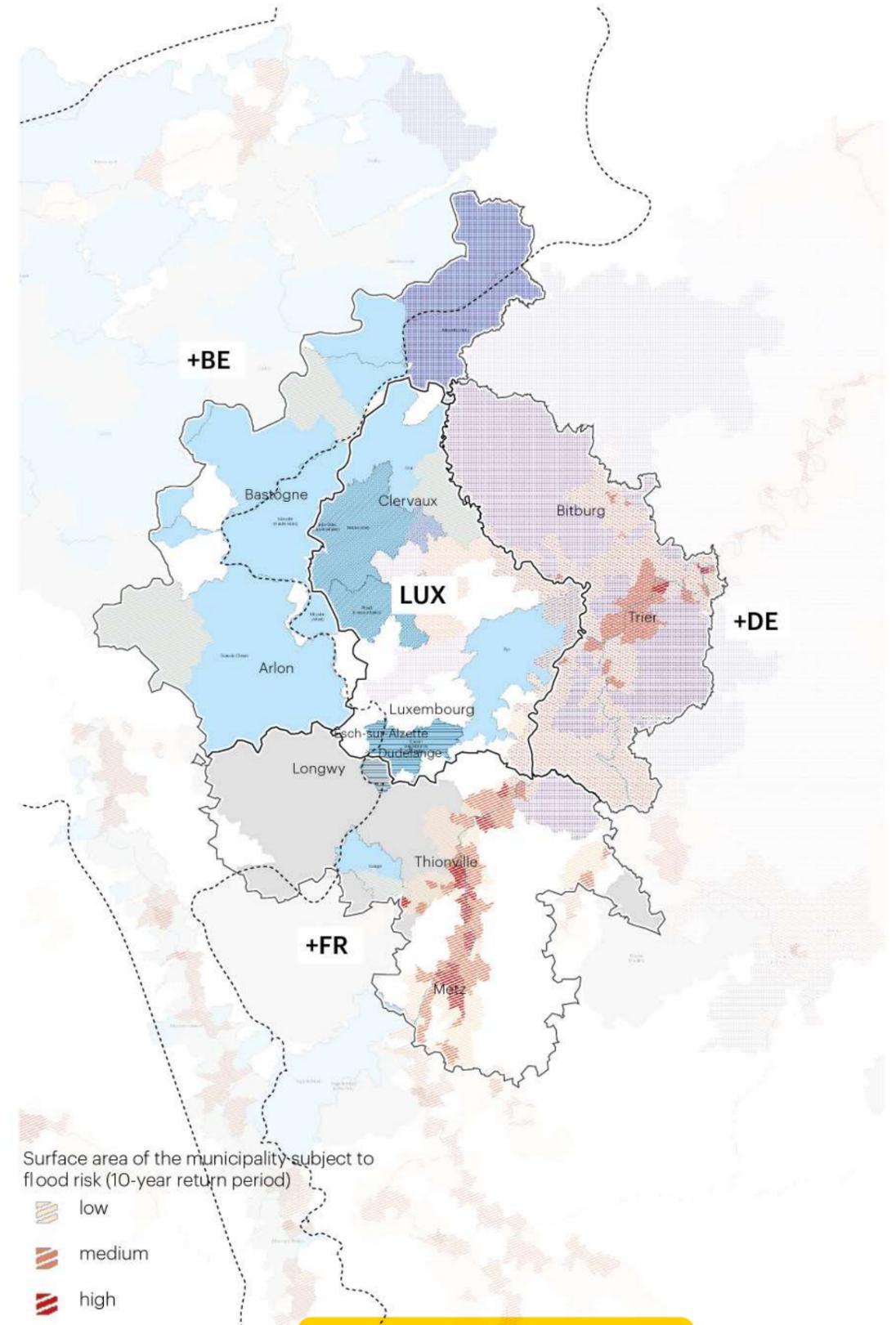


Remerschen





Soil Sealing



Cross-border Flood Risk Management

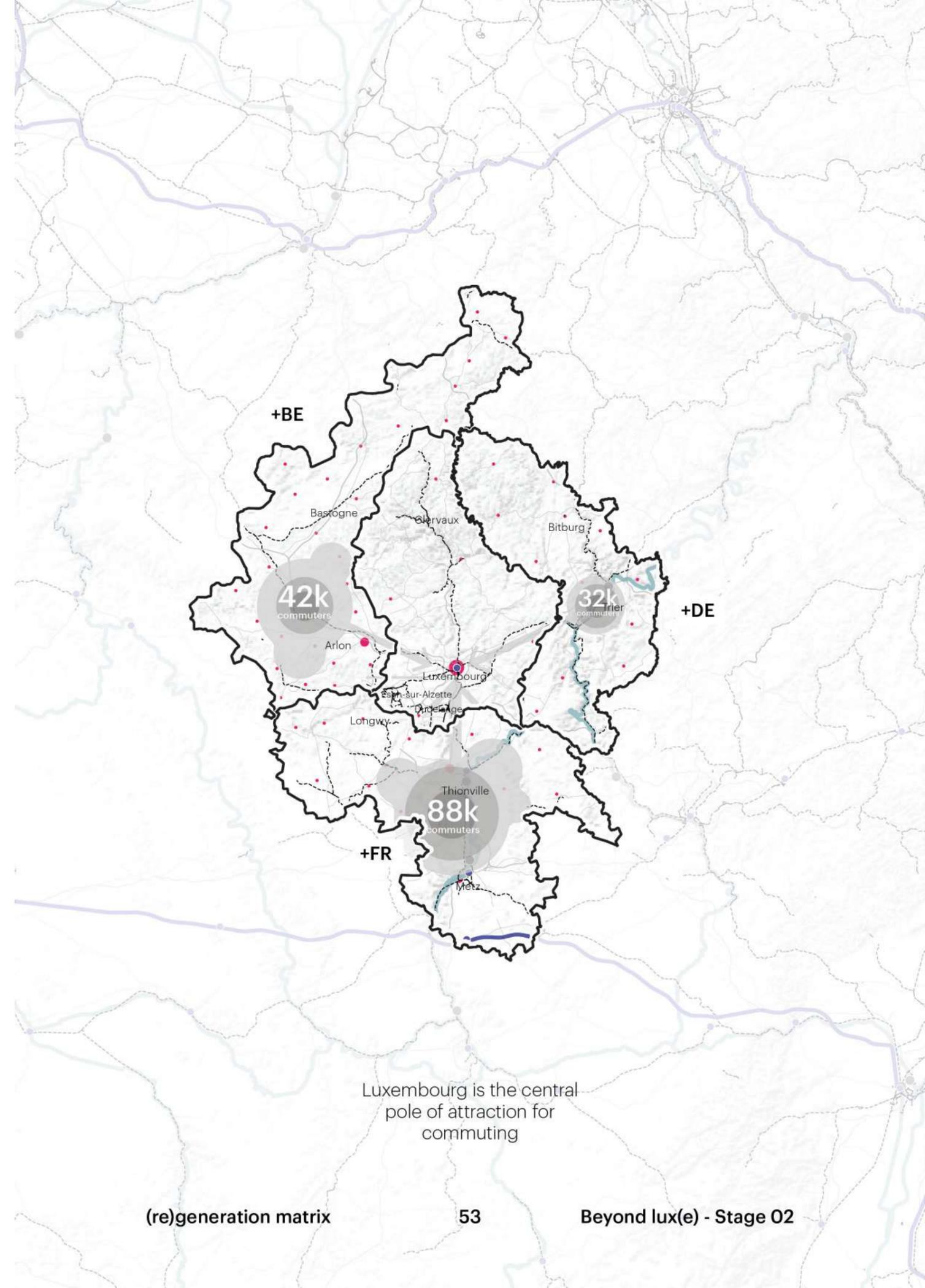
Mobility

In the Functional area's cross-border context, transport networks (road, rail, water, air) often reflect their national administrative area.

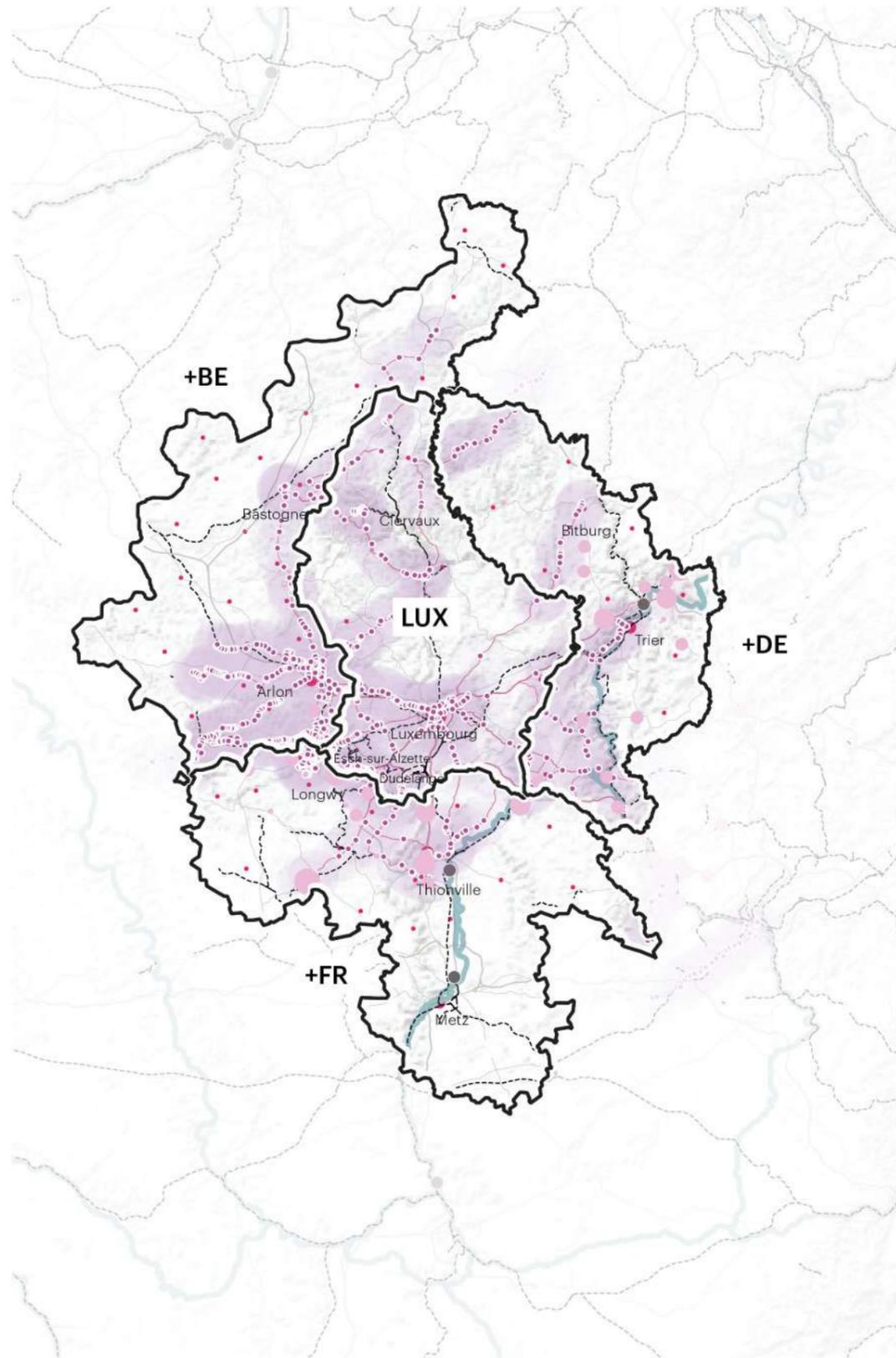
Between France, Belgium, Luxembourg and Germany, there are discontinuities in the transport infrastructure as well as in the service offerings associated with them. There are cross-border bus lines and rail lines linking the most populous cities to Luxembourg. However, the mobility system is strongly based in individual cars, and there is not enough infrastructure to support car-pooling and electric vehicles. The territory is also organized in a way that prioritized the links from the neighbouring regions to Luxembourg, neglecting domestic accessibility. This siloes small villages from job opportunities, access to care and amenities. In the prosperous Luxembourg, transit has recently

become free from ticketing. Around Esch-sur-Alzette and Dudelange, new lines are being implemented to address domestic transportation and relief the conflict with commuting from France. Enhancements in the TGV connection are a step in the right direction of decarbonization. However, the provision of fast and convenient mass transit is not offered in the same manner to German or Belgian urban centres.

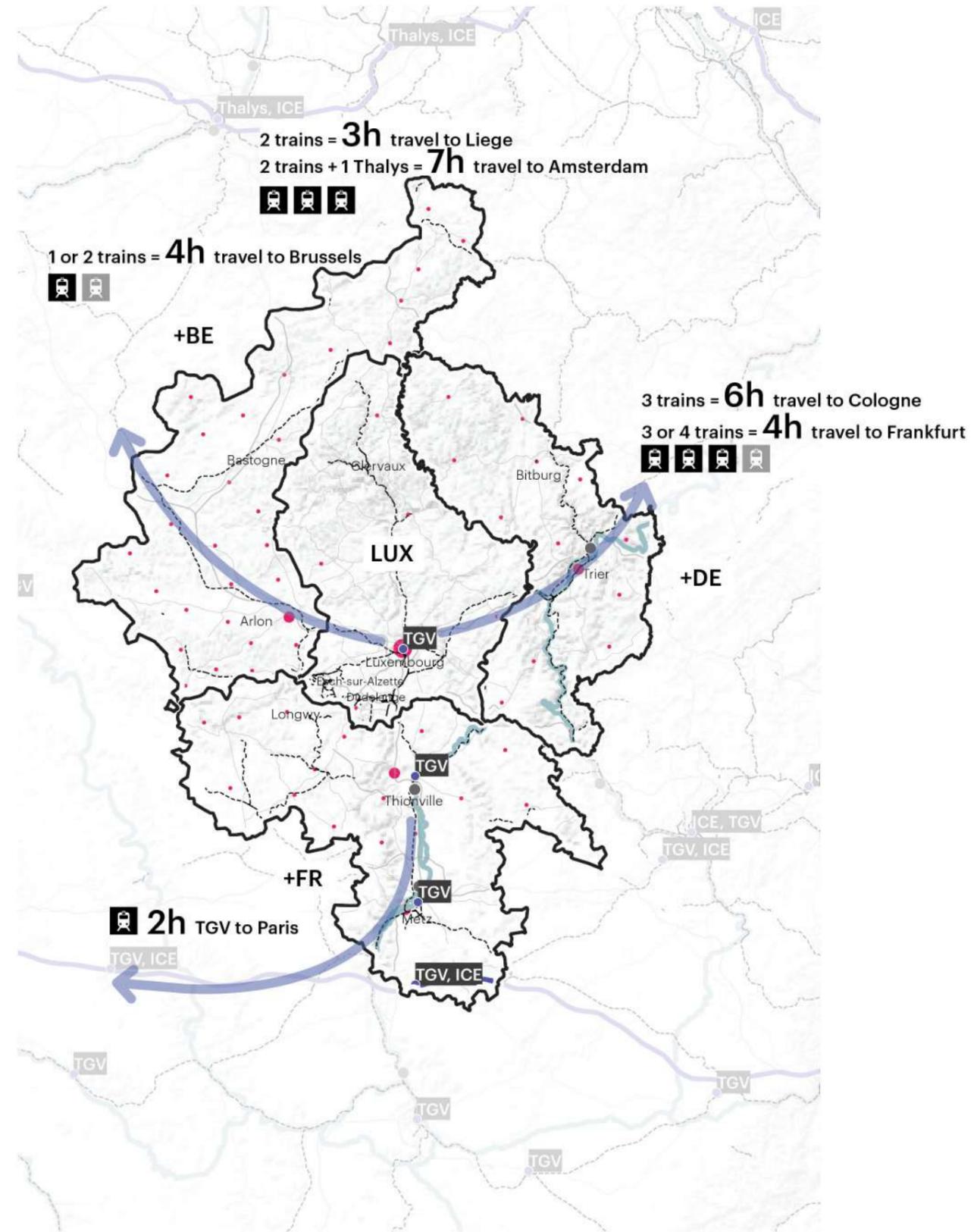
To achieve zero-carbon and a resilient future for the Functional Area, **there has to be more cohesiveness in the structuring of the cross-border area. It requires planning land-use at the local scale, to provide program and services close to where people live. It requires a great effort to rebalance taxation of goods, and housing offer and affordability across the region, to discourage long trips for basic daily needs.**



Luxembourg is the central pole of attraction for commuting



Cross-border links by bus and Park and Ride Locations



International links by Public Transportation is fast or convenient

Waste

Although Waste represents a small portion of energy consumption and carbon emissions in the Functional Area of Luxembourg, it is a transversal subject for our regeneration goals in the cross-border area. To achieve a truly resilient and decarbonized future, waste should give place to an effective circular economy.

In the SaarLorLux area, there is a lack of integration in the waste treatment practice, and in the transparent, standardized manner of accessing information about this topic.

One of the biggest challenges that our team came across in Stage 2 of Luxembourg in Transition was to find circularity information for the Functional Area.

At the national level, Luxembourg launched the Circularity Dataset Initiative to address the difficulty for industry and consumers to access

reliable data on the circular properties of a product. The goal is to assemble a standardized Product Circularity Data Sheet (PCDS) to congregate information about waste.

By analysing national data for Luxembourg, it was possible to understand that the waste industry is not performing on its best. Although recycling rates are practically absolute, plastic and wood are the least recycled materials.

Much of household waste ends up in the only landfill of the Grand Duchy. Inert waste has no place for disposal and together with industrial waste, much of it is exported or incinerated. Such practices are a challenge to decarbonization because of their indirect contribution to CO2 emissions.

" My town is not a dumping ground " asserts the mayor, Daniel Cimarelli. Since 2014, he has been fighting against the comings and goings of Belgian trucks and French and Luxembourg cars which deposit their garbage in his forest. Bottles, plastic bags, pieces of tiles, tins, papers, used oil... Nothing is spared in this town of 1,000 inhabitants. (Les Frontaliers,2020)

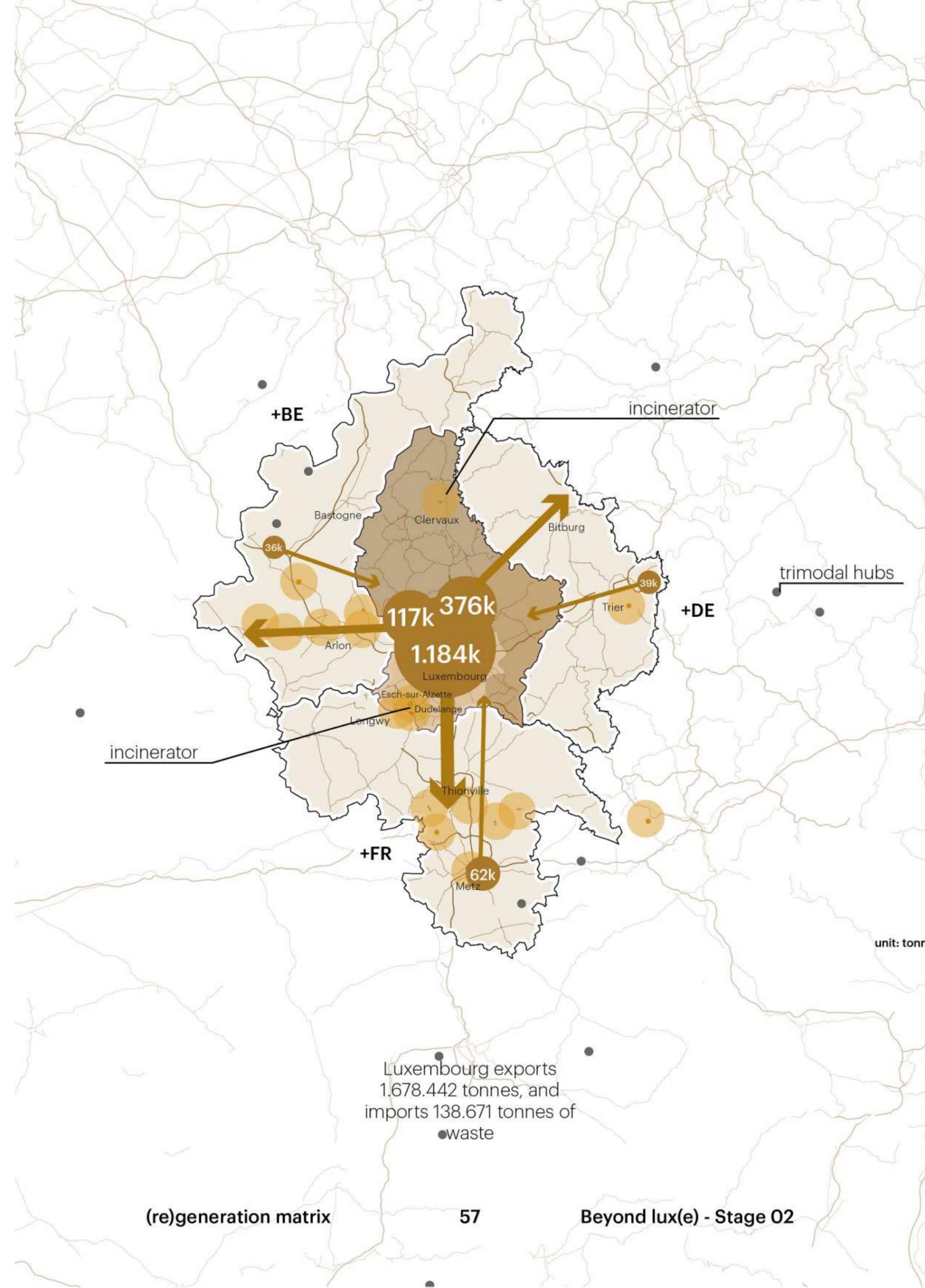


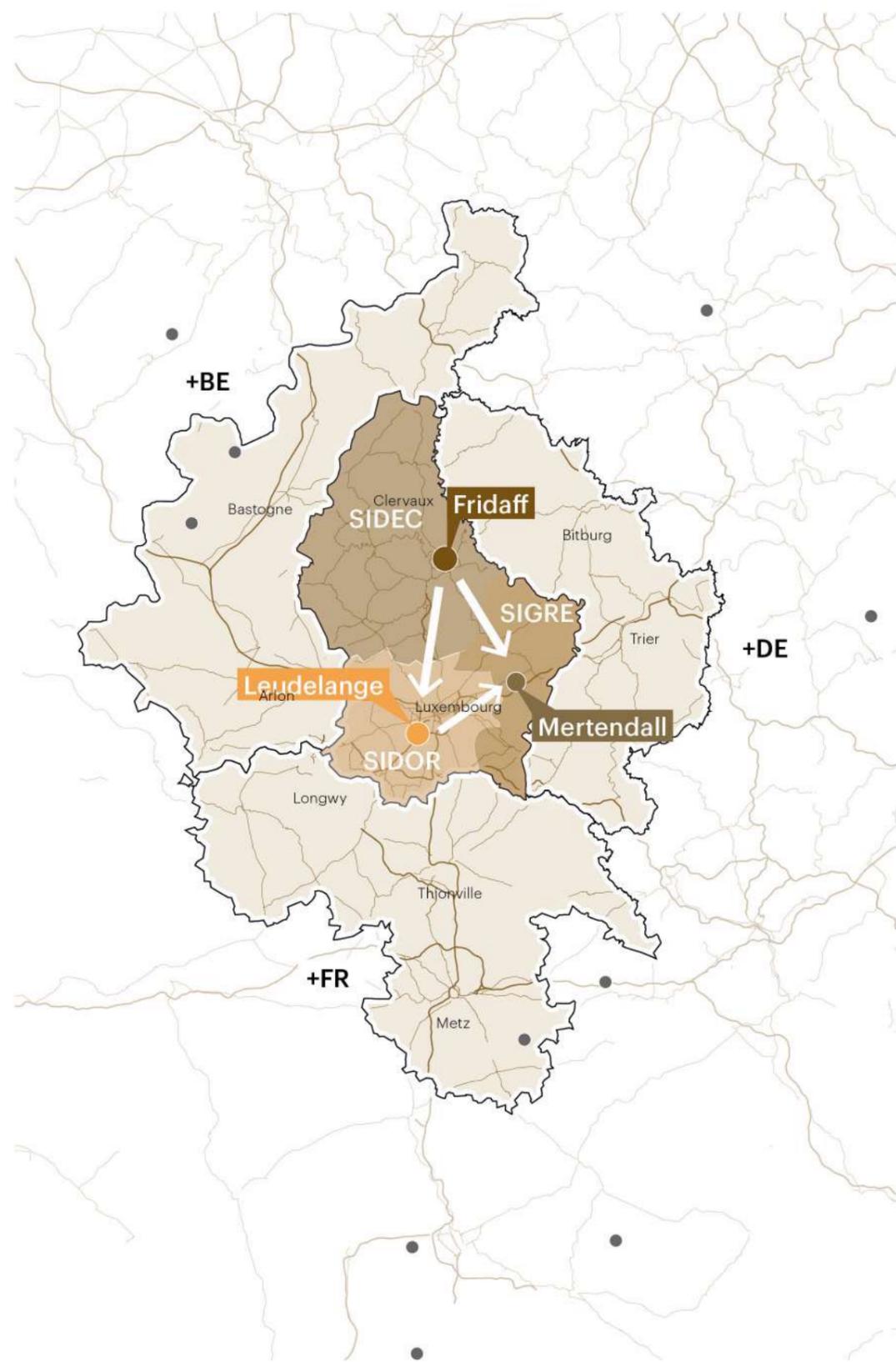
Incineration plant

<https://www.lesfrontaliers.lu/societe/dechets-a-redange-deux-pays-frontaliers-dans-le-collimateur-du-maire/>

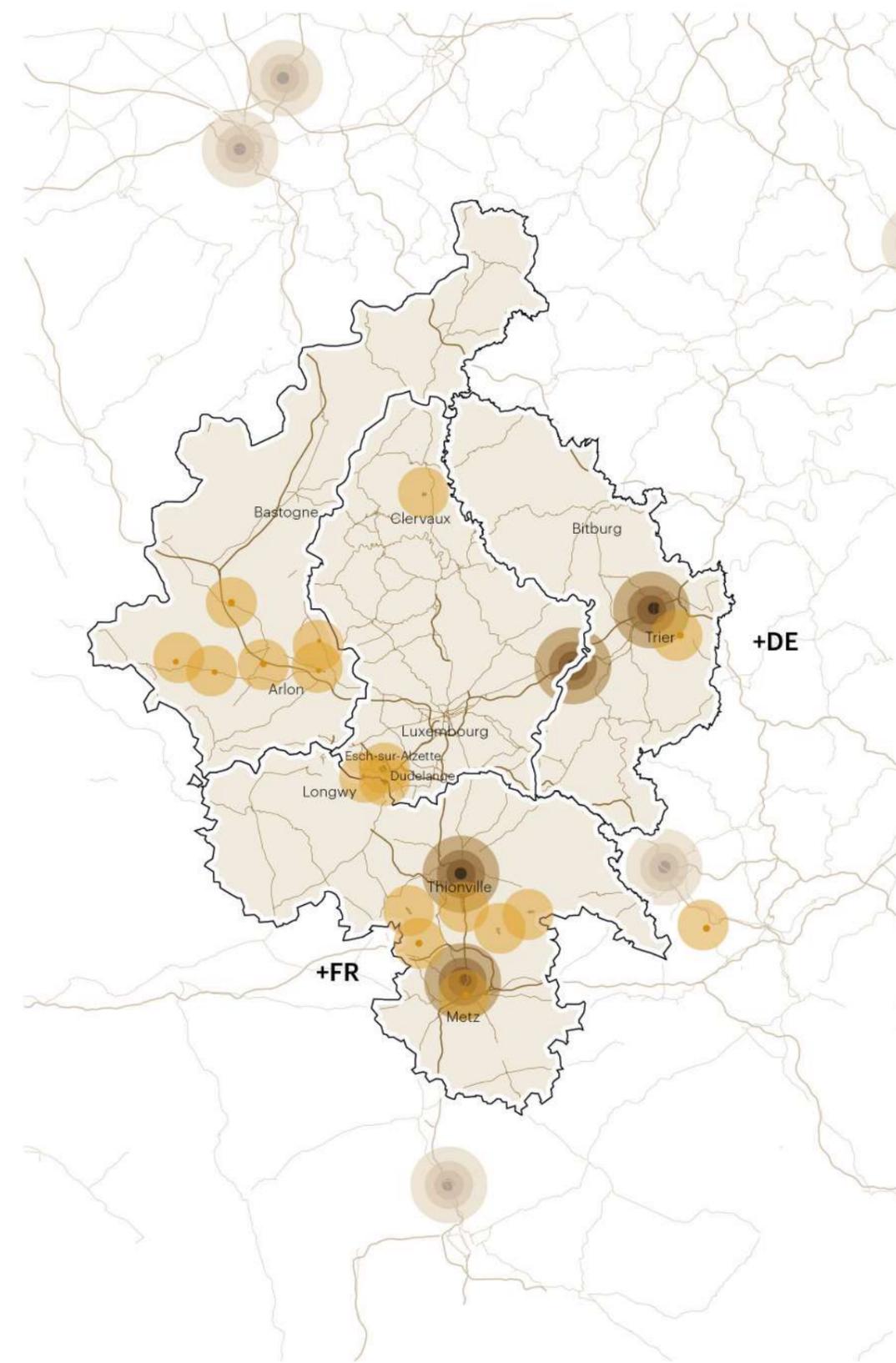


Informal landfill in Redange, Luxembourg

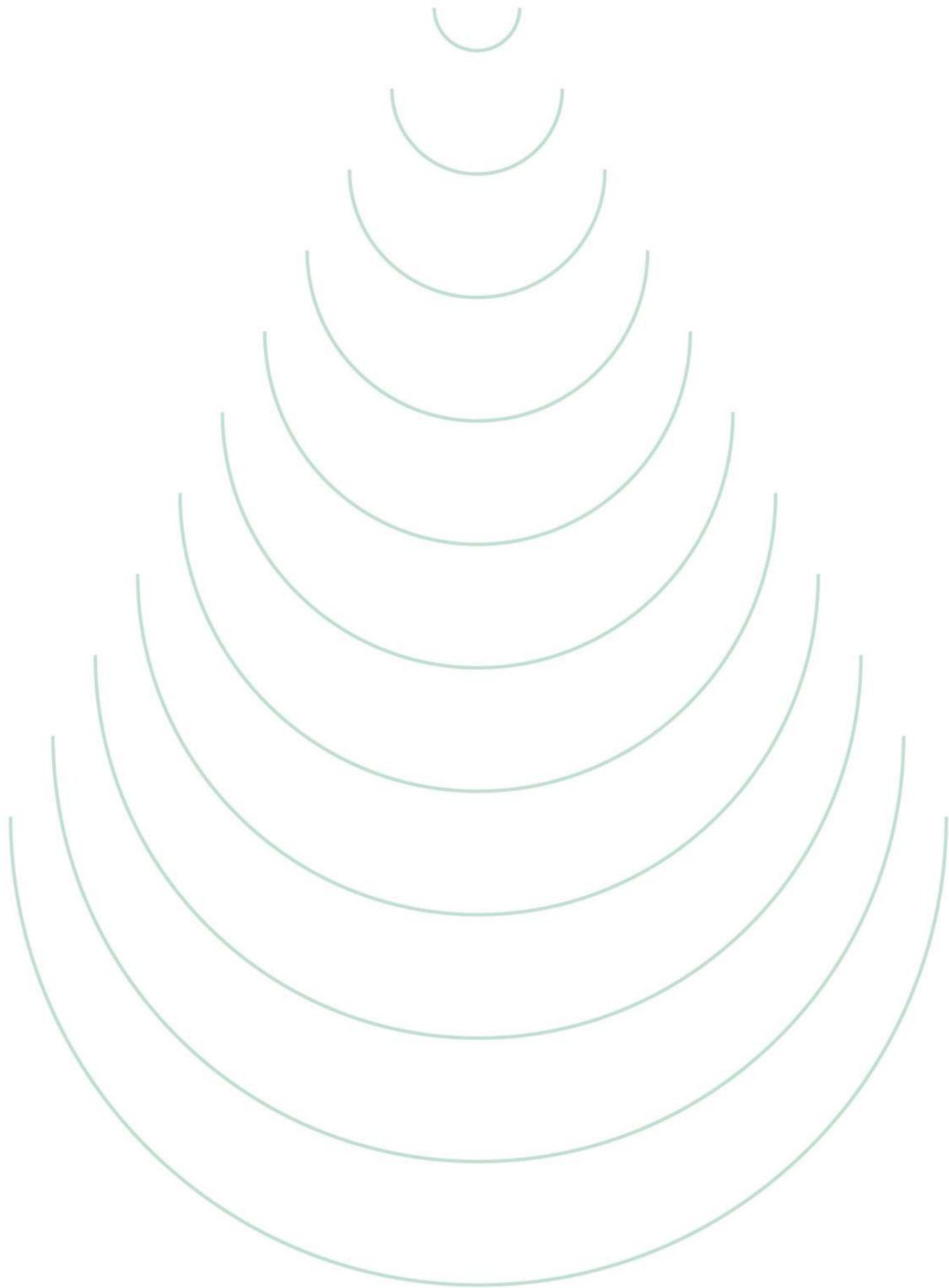




3 complementary waste management districts in Luxembourg



Landfills and recycling centres in the Functional Area



Growing and
Shrinking
region

The estimated growth by 2050

Knowing that our vision will surpass zero carbon, means we need to reflect on the kind of territorial composition we envision for 2050. Today, the Functional Area faces one of the most important challenges in European urban development: the dichotomy of rapidly growing cities and shrinking rural spaces.

The country of Luxembourg adheres to a mono-centric urban growth pattern, attracting and generating a centralized mobility dependency. This is evident in the forecasted patterns. The country will grow by an average of 47,6%. This is not equal in every municipality, since the current territorial model is to grow according to a mono-centric approach, then the City of Luxembourg concentrate a larger percentage of this population growth. This dynamic extends beyond the city itself to the main infrastructural corridors, generating the three key growing areas (Luxembourg City, Trier, Metz, and Arlon).

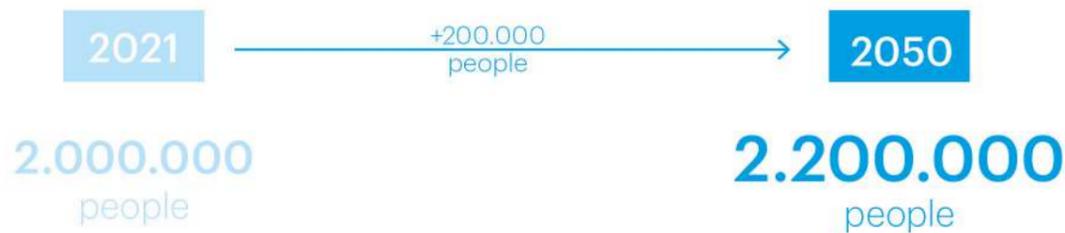
If we look at the Functional Area, then we can see that growth tendencies vary substantially. Luxembourg the country grows intensively towards the south and forms key infrastructural connections to Belgium, France, and Germany. In other parts of the functional area outside the country, we see counties in Germany shrinking, and in Belgium and France a lower estimated growth rate compared to Luxembourg the country.

It is clear that there is an imbalanced urban growth pattern. However, if we look at the Functional Area as one entity, we will find that rapid growth and shrinkage can balance to an average growth of 14%. This means, from the population of 2 million currently living in the Functional Area, we estimate that the additional 200.000 people can spread across the major cities, with a great portion of these in the City of Luxembourg.

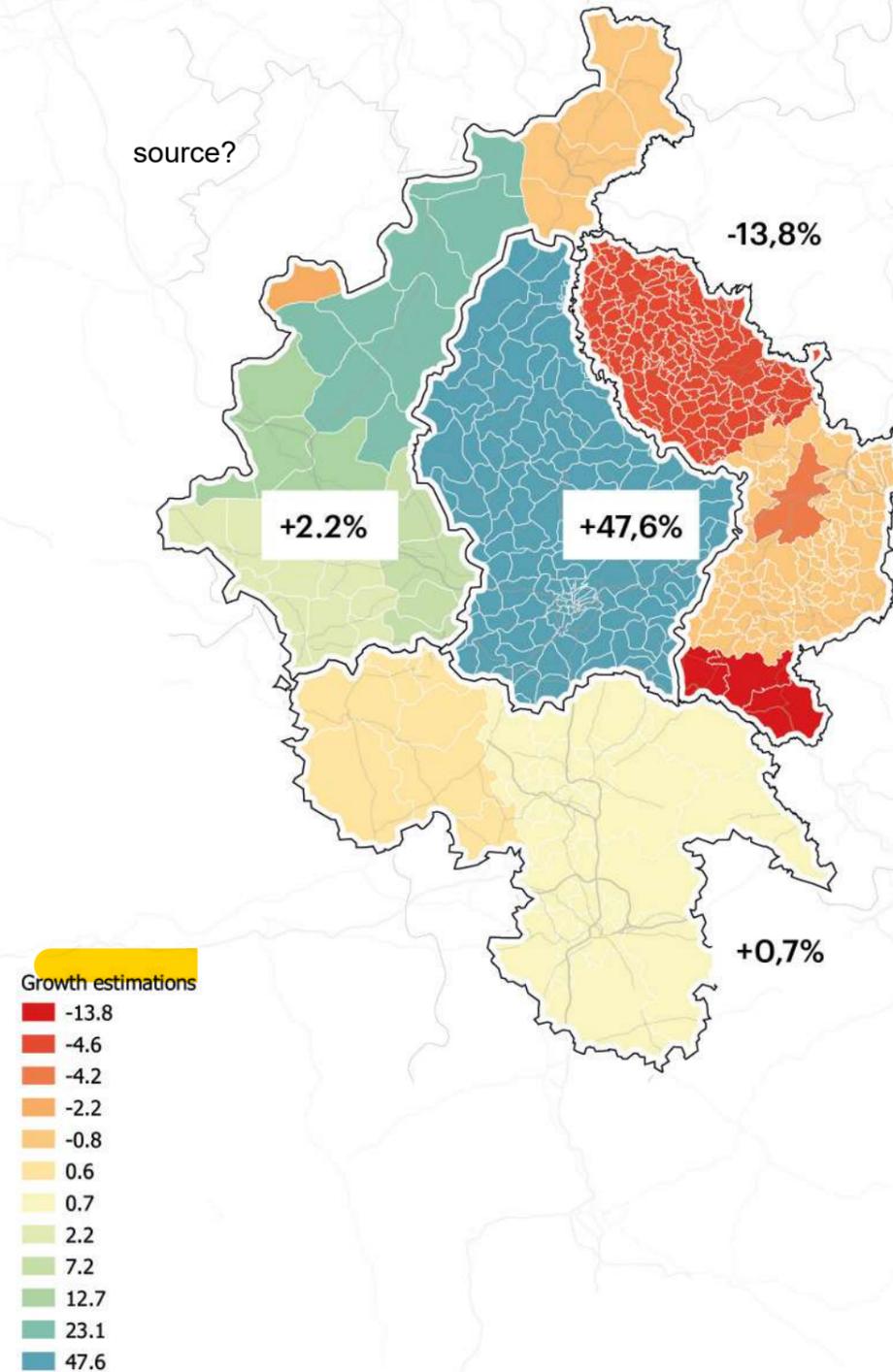
Our goal is not to just accept these growth patterns, but to try to balance them with the requirements of a more (Re) generative urban growth system.

Doing this, we aim to analyze the specificities of the settlement patterns, not only in terms of growth conditions but also according to other key parameters which define their diversity. This enables the elaboration of potential opportunity areas for settlements which can balance development and growth.

The specificities arise from an understanding of density distribution, growth patterns, clustering in rural areas, and the relationship with natural and rural land use.



source?



Density today

75% of sett.
 1168 sett.
 0-2000 inhab/skm2
 779 km2



23% of sett.
 85 sett.
 2000-4000 inhab/skm2
 244 km2



1,5% of sett.
 12 sett.
 4000-6000 inhab/skm2
 15 km2



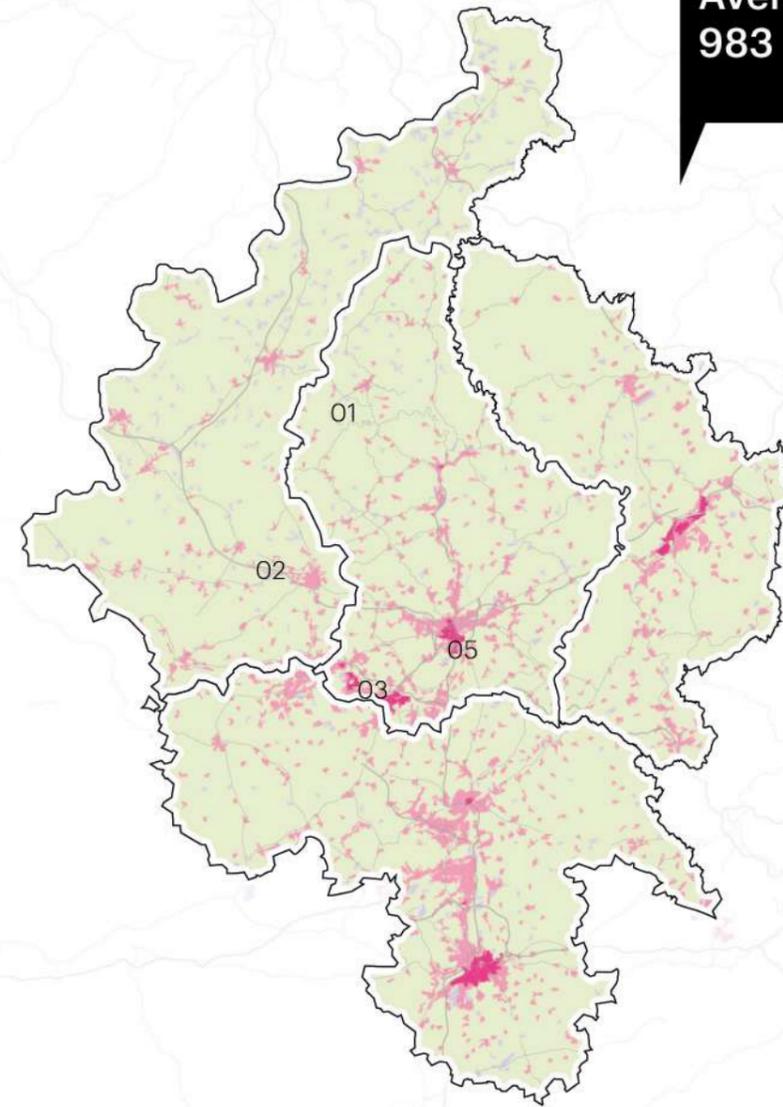
0,6% of sett.
 2 sett.
 6000-8000 inhab/skm2
 6 km2



0,1% of sett.
 1 sett.
 >8000 inhab/skm2
 1 km2



1269 settlements
1043 km2
Average density:
983 inhab/km2



Low
 Medium
 High

Growth by 2050

Growing

26% of sett.
 327 sett.
 > 30% of population
 274 km²



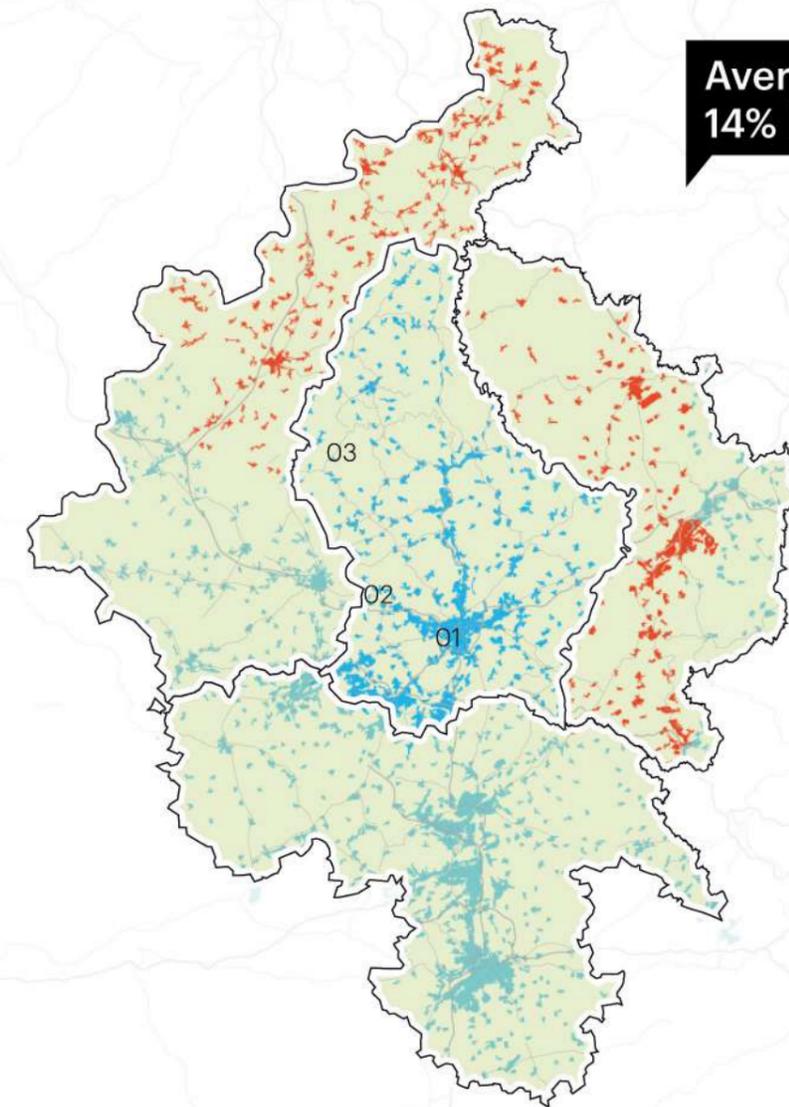
Stable

53% of sett.
 651 sett.
 0-30% of population
 554 km²



Shrinking

21% of sett.
 288 sett.
 < 0% inhab/skm²
 214 km²



Average growth:
 14% by 2050



Clustering level

Connurbated

33% of sett.
269 sett.
> 10 sett around
340 km2



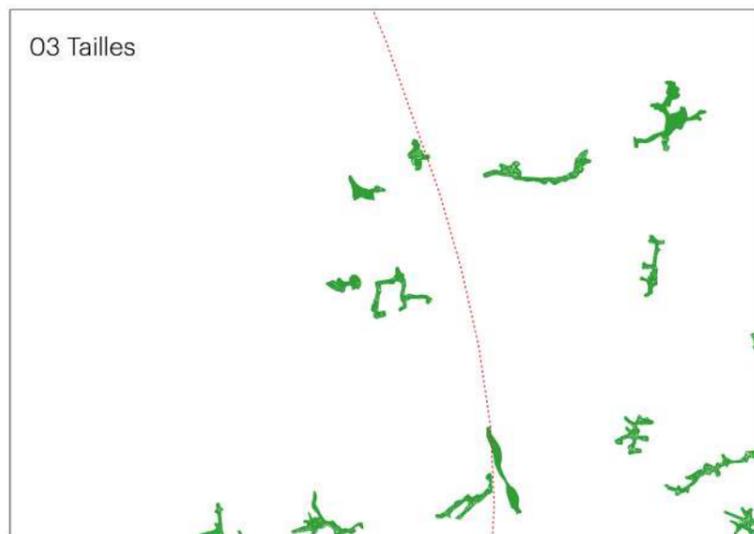
Clustered

52% of sett.
727 sett.
3-10 sett around
542 km2

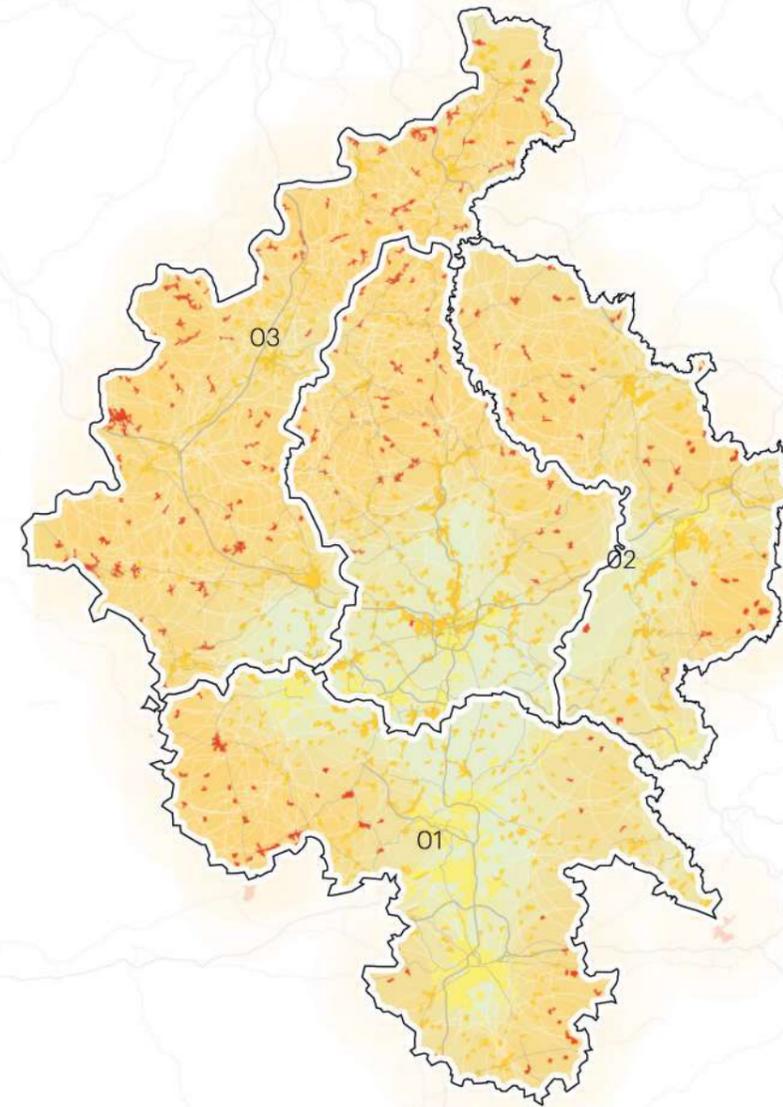


Isolated

15% of sett.
273 sett.
0-3 sett around
162 km2



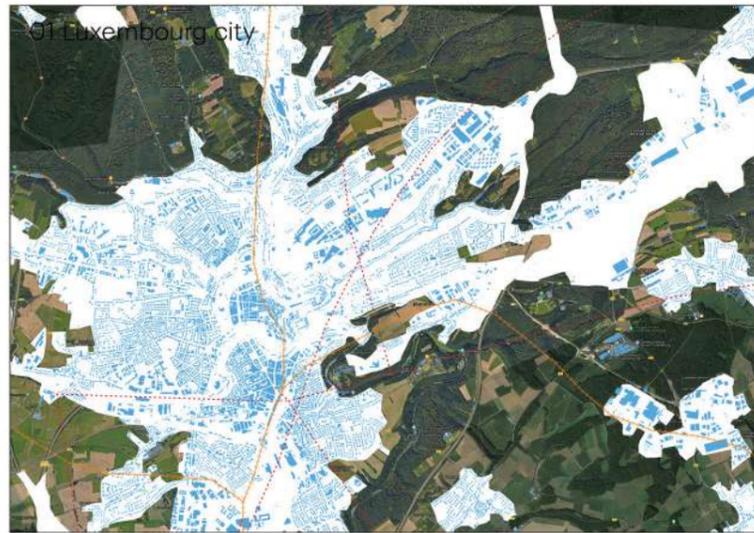
Average of 10 settlements per cluster



Relation to nature / rural

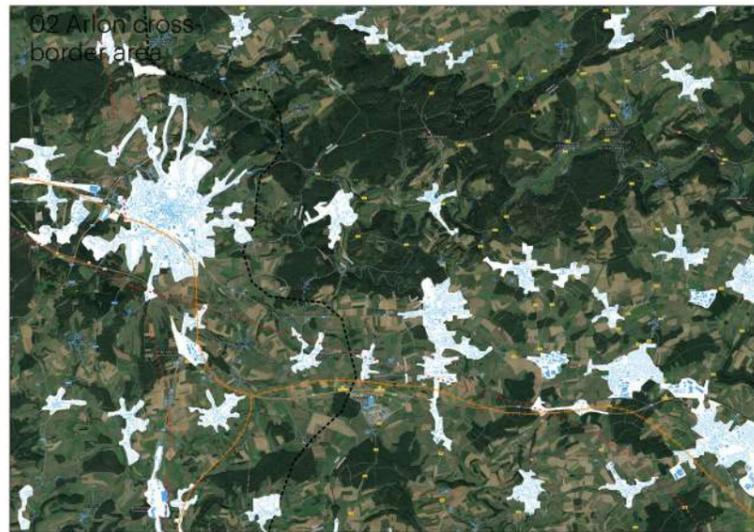
Urban

47% of sett.
 366 sett.
 > 50% Urban
 495 km2



Rural

42% of sett.
 740 sett.
 > 50% rural
 443 km2

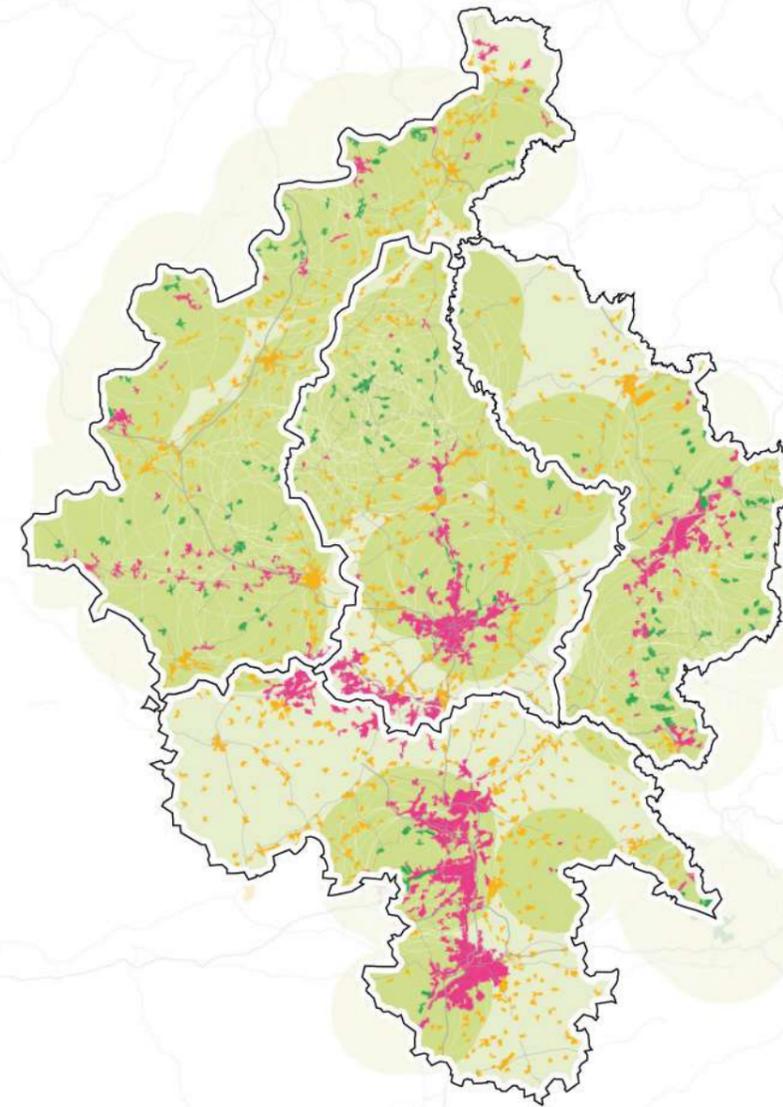


Natural

11% of sett.
 163 sett.
 > 50% natural
 105 km2



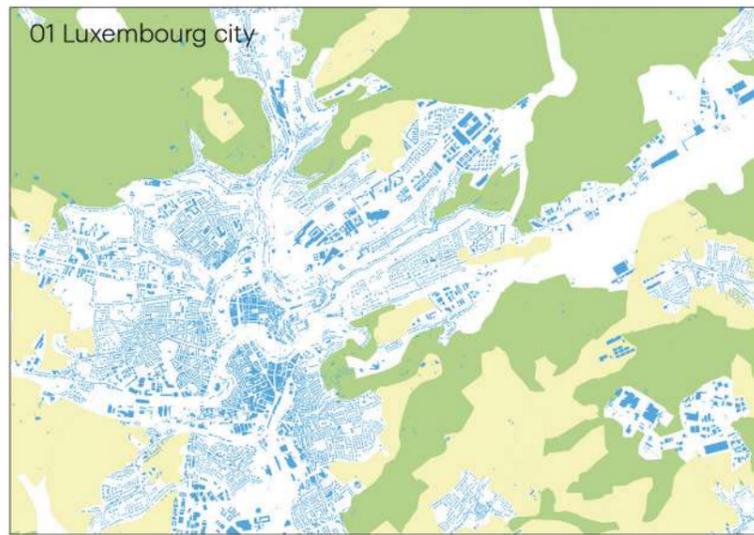
Mostly rural and natural settlements



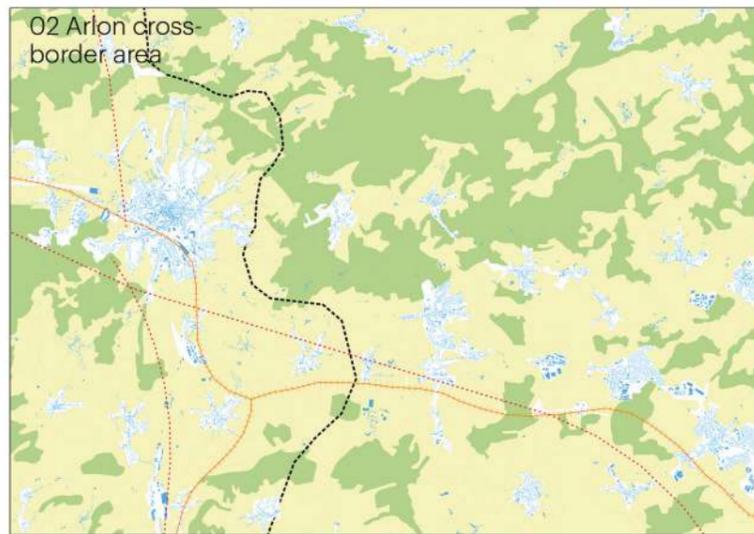
- 10 km buffer surrounded > 50% of forest
- Natural settlement >50% forest
- Rural >50% rural
- Urban >50% urban

Opportunities and Challenges

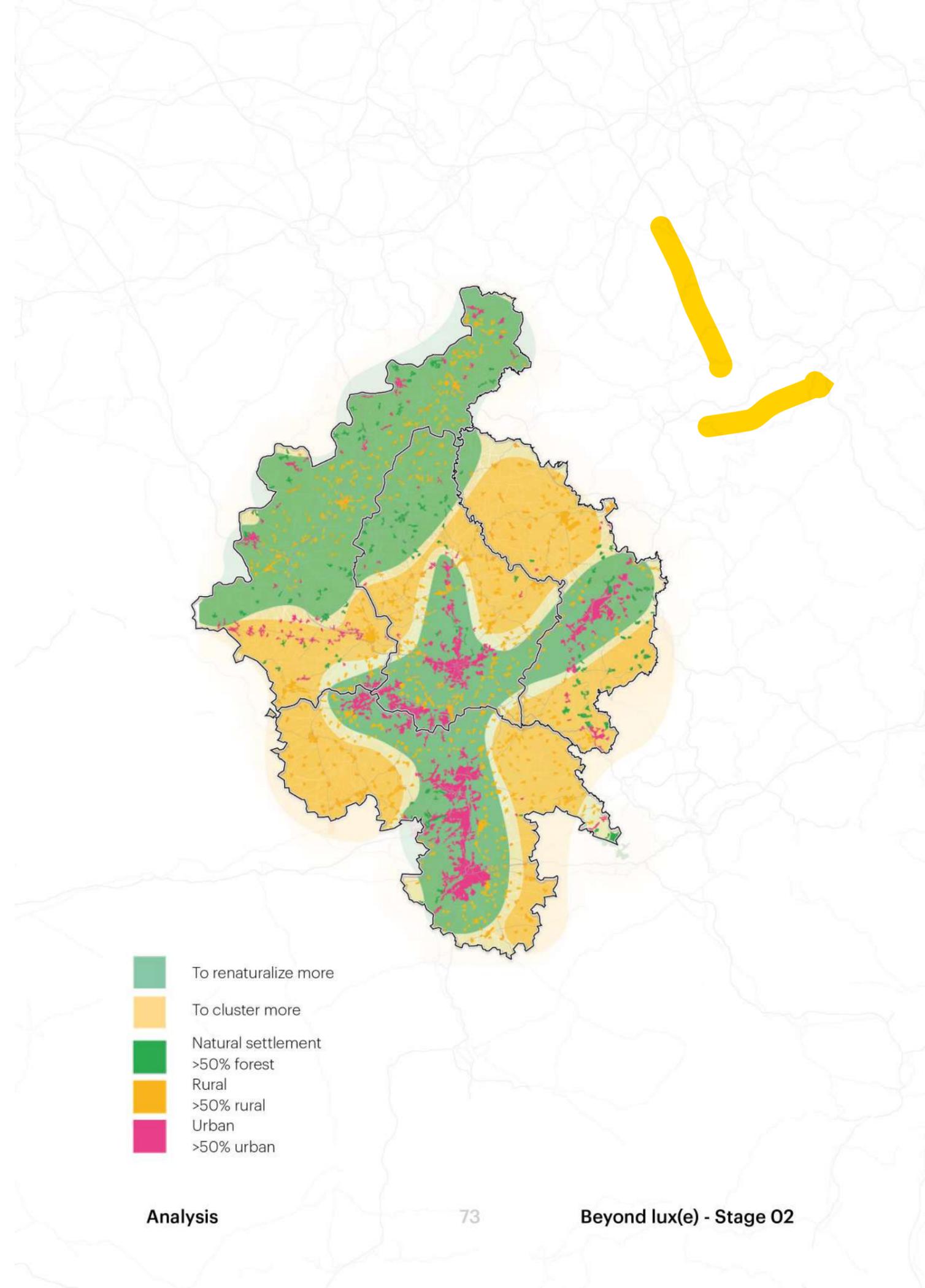
Balancing urban and nature



Clustering for self-sufficiency



Equipping natural systems



- To renaturalize more
- To cluster more
- Natural settlement >50% forest
- Rural >50% rural
- Urban >50% urban



Ecological
Fragmentation

Fragmented landscape

Land-use change has a direct impact on habitats and their ecological connectivity. In the Functional Area of Luxembourg, urbanized land and infrastructure causes landscape fragmentation and increased soil sealing. As a country, the Grand Duchy is one of the most habitat fragmented countries in the EU. With the accelerated growth rate that is predicted here, the southern portion of the region tends to intensify land use change towards urbanization.

Such man-made alterations contribute for habitat loss and for a territorial fragility in the long term, concerning climate change.

The preservation of nature and landscapes entails in intense cross-border collaborations. At the greater Region scale, the establishment and conservation of Natural parks are essential to ensure the maintenance or restoration of biodiversity.

The concept of an ecological network is a response to the challenge of integrating regional strategies to allow plant and animal species to develop and move freely across the territory.

In most States / Regions, the materialization of this network is ensured by the implementation of the pan-European network of Natura 2000 sites.

The French portion of the Functional area, Lorraine, is particularly deprived of Natura 2000 sites or complementary protection sites. The link with neighbouring countries are mainly provided by reservoirs, most of them not listed in Natura 2000 or as strictly protected sites.

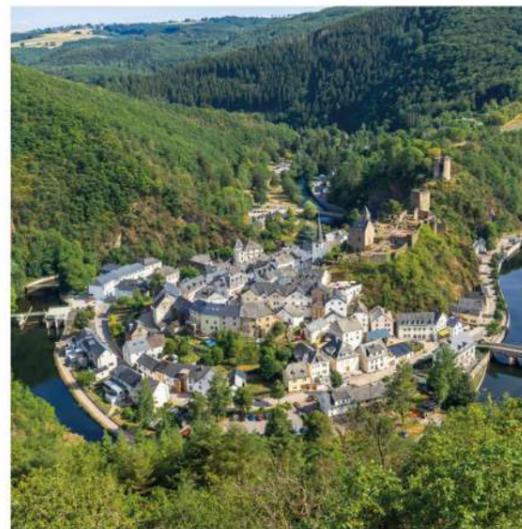
In Luxembourg and Saar-land the sites are of a reduced size and disconnected from each other. In Wallonia, the sites have a larger size and between Bastogne and Wiltz, there are important cross-border continuities.

Water quality and ecological potential of the surface bodies of water are determinant of biodiversity and climate change resilience. The North portion of the Functional Area is mostly covered by forests. The southern portion has an expressive coverage of agriculture land and pasture, that do not carry sustainable practices. The Nitrates from farming fertilizers affect directly the quality of the bodies of water in this location, that are mediocre or low.

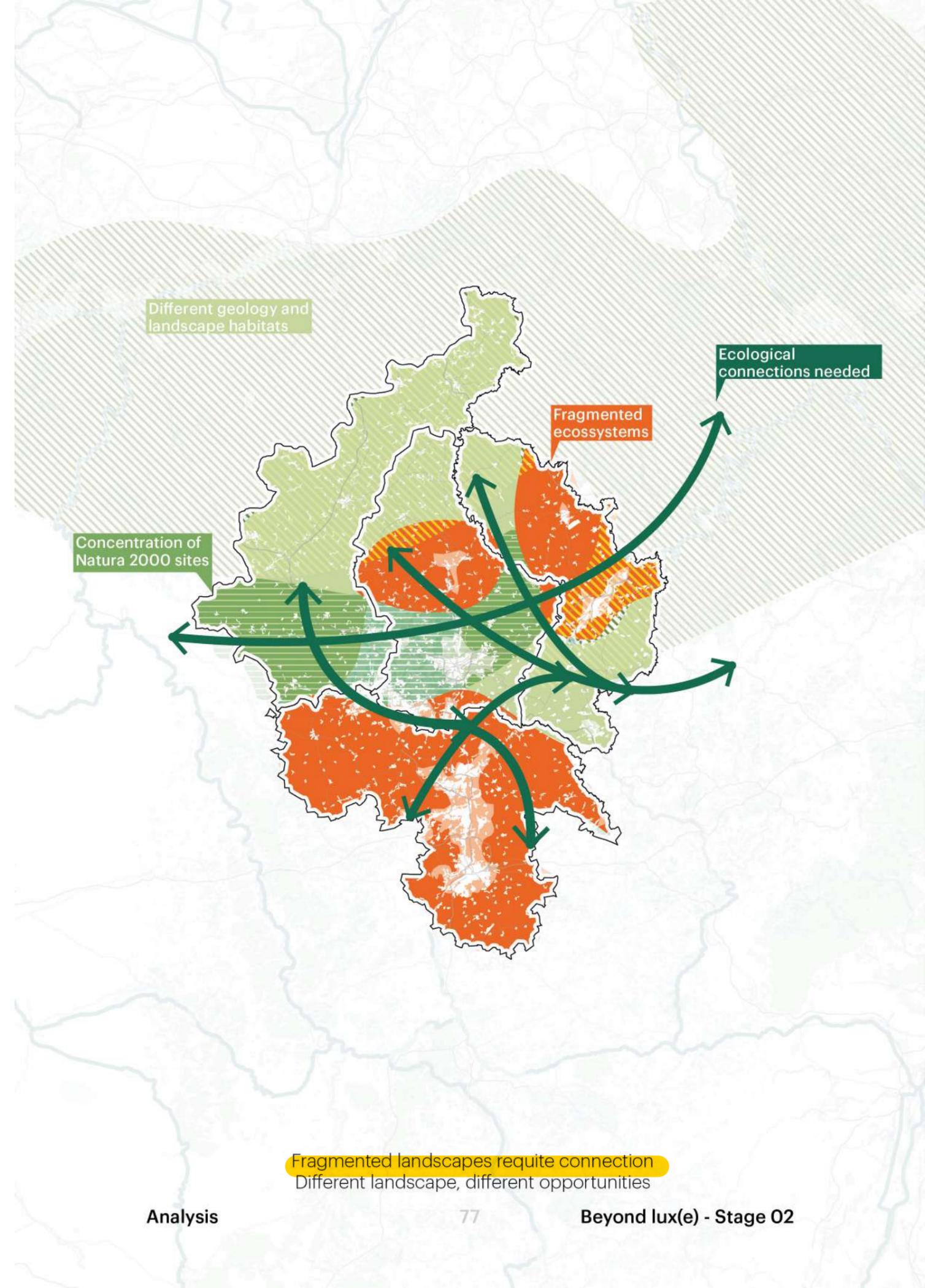
The difference in the qualitative state of water illustrates how practices follow local/national policies and require a stronger integration across the Functional Area.



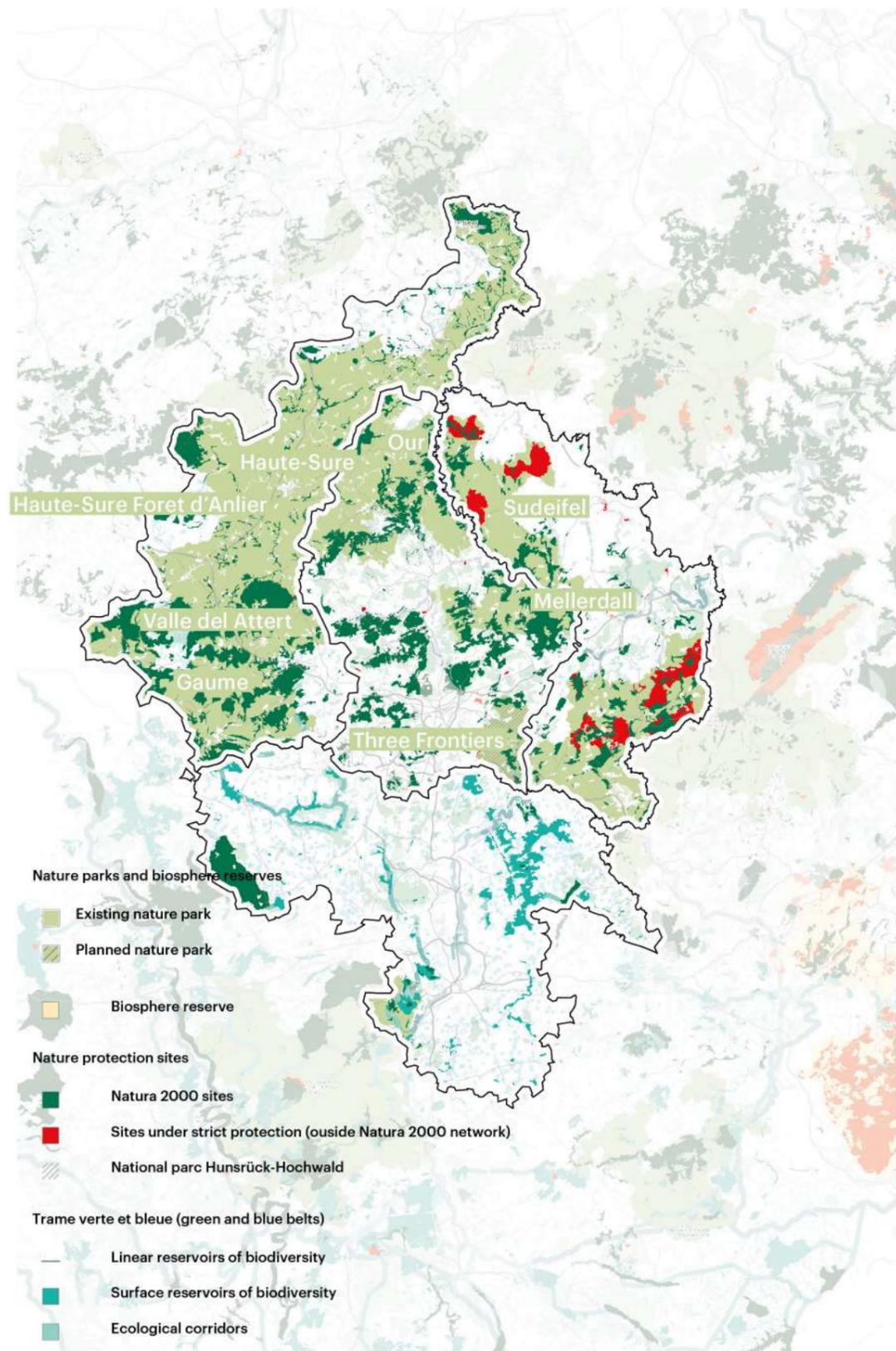
Our (Sure), an important site for cross-border ecological continuity. North of Luxembourg and Germany.



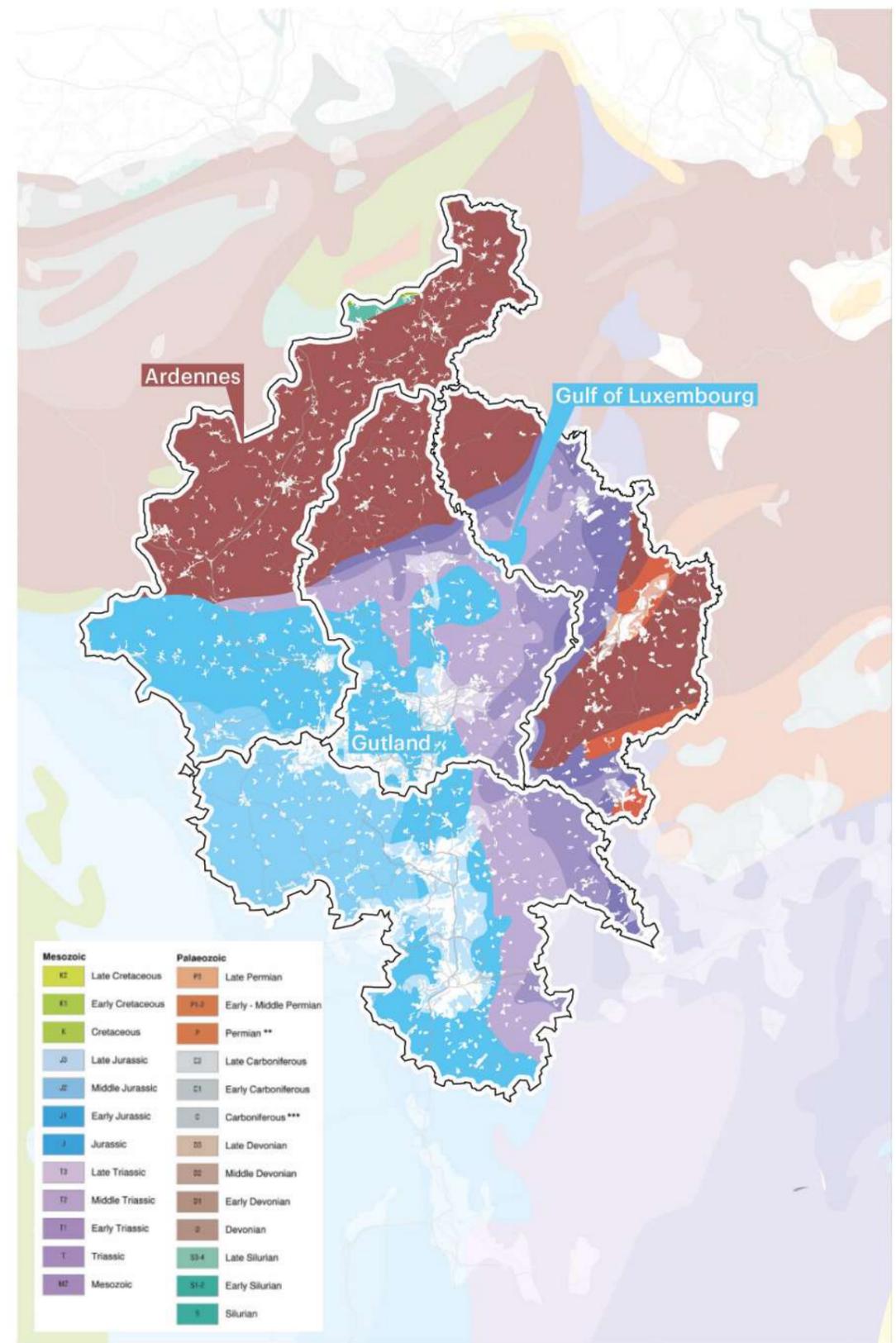
Wiltz, an important site for cross-border ecological continuity. Luxembourg and Basogne (BE)



Fragmented landscapes require connection
Different landscape, different opportunities



Protected areas



Different geology, landscape and opportunities

Balancing shrinking and growing

In the myriad of settlements, we look for opportunities to showcase where to intervene and how to go about it.

In the myriad of settlements, we look for opportunities to showcase where to intervene and how to go about it.

Lux+ is mainly rural, and while there are some hotspots where density concentrates and growth is rapid, the reality of the majority of the territory is rural, clustered, quite close to nature, and very dependent on central cores. This generates an imbalance in the territory, and these growth patterns determine future dynamics. More of this mono-centric growth demands more mobility, a more centralized footprint, more dependency at the regional level and in conclusion, more unsustainable living conditions.

Therefore, opportunity areas emerge as areas where we define, allocate, and aim to integrate existing settlement challenges with natural conditions.

To do this, a set of criteria help to define strategies for sustainable urban growth. The three strategies are:

Intensification: if a settlement is experiencing growth, within predominantly urban surroundings, and is medium to high density, it is a potential opportunity area for intensification. Potential footprint demand balances growth to ensure that growth should take place in a sustainable manner and prevent seal soiling.

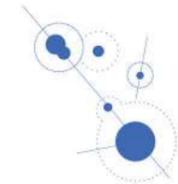
Renewal and/or transformation: if a settlement is experiencing growth, is medium to low density and has a strong relationship to the natural environment (forest or rural) then it has potential as an opportunity area for transformation and renewal. With this is a stabilizing approach, where intense growth in hotspots moves here, promoting a self-sufficient clustering of settlements to avoid mono-centric dependencies.

Re-purposing: if a settlements has low density, has a shrinking population, and is surrounded by nature, then the settlement will transition into a re-purposing pattern in the future. This could mean that it acquires a new program, with new functions, to accommodate the natural environment, or to support rural production environments.



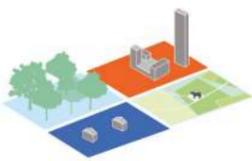
Population Growth

- Low density and shrinking
- Medium density and stable growth
- High density and accelerated growing



Settlement Configuration

- Isolated from other settlements
- Nearby or clustered with other settlements
- Crowded and conurbated with other settlements



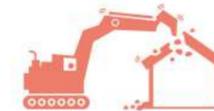
Land-use surrounding

- Mostly natural or mostly rural
- Mosly balanced (natural + rural + urban)
- Mostly urban

Re-purpose



Renew/Transformation



Intensify



Enhance self-sufficiency within lux+

The cross-border dependency analysis leads to the conclusion that in order to maximize the considerable opportunities that the Functional Area has, it must become more self-sufficient, and therefore, consolidate the current practices and regimes into more (Re) generative systems.

In order to do this, lux+ requires an understanding of how much space is necessary for each theme to support both self-sufficiency and zero-carbon ambitions.

These two principles ensure maximized localization of consumption and production. This supports a reduction in distribution, infrastructure demand, and generates practices that create an awareness of the limits of our natural systems. In essence, this triggers a behavioural change to support a more sustainable lifestyle.

Unfortunately, space is limited, and available space has its own specificities. The analysis on the five key themes identifies a significant opportunity to generate circularity in the systems, and besides this, lays the foundation to generate synergies.

To optimize space, the strategy must involve the development of innovative technologies that support the allocation of different themes in one single space to generate synergies.

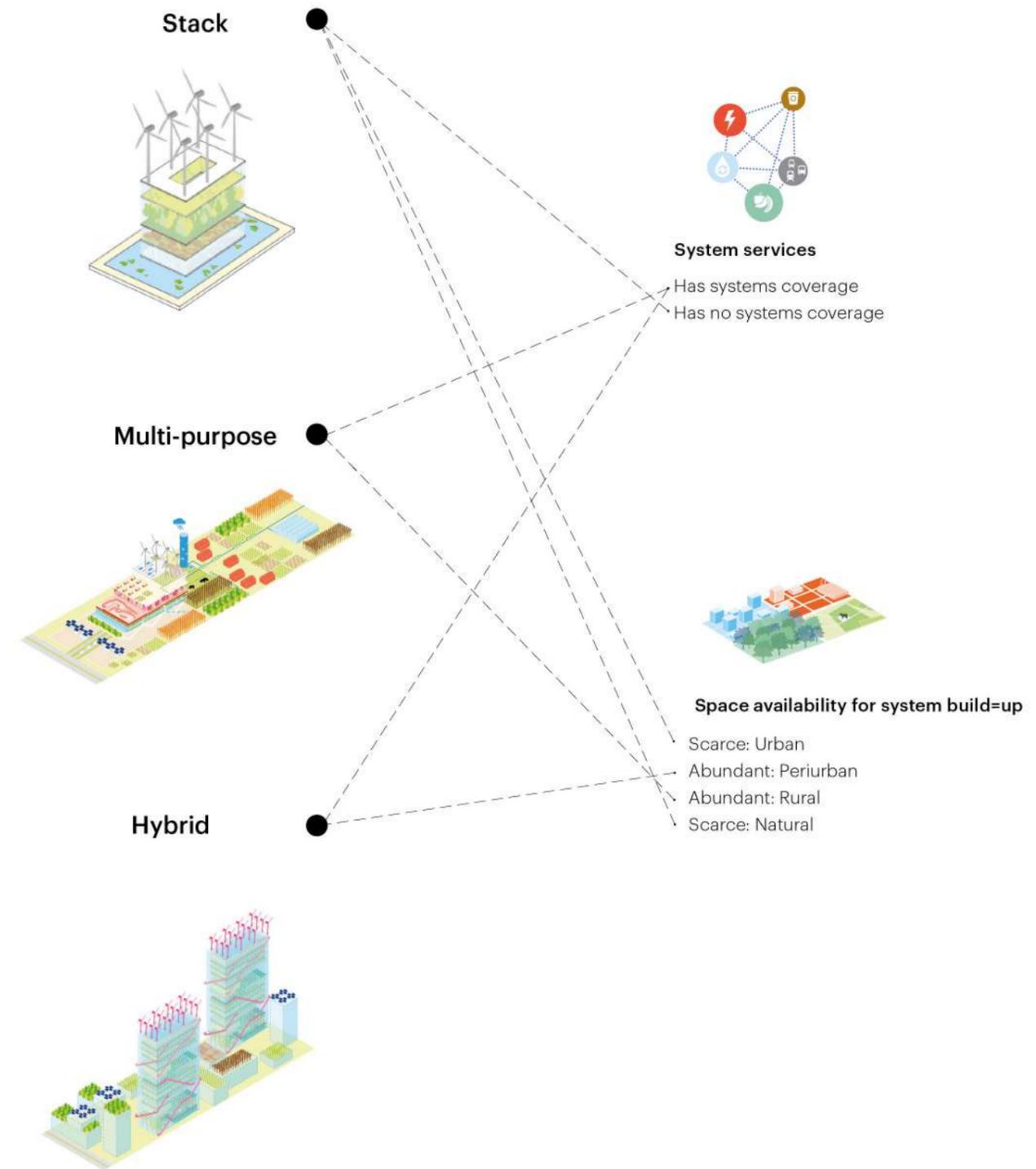
Defining where and how the five themes could couple or stack means that the multi-functional use of land helps to optimize space.

Three strategies emerge from the analysis:

Multi-purpose: when land is extensive, but only fulfils a single purpose (i.e. agriculture, forest, peri-urban, or even vacant space) couple different functions on the space to help each enhance performance and at the same that optimize the space. For example: productive forests, agricultural pv lands, or urban and water collectors. Each space plays a role in contributing to others, and at the same time ensuring that every theme generates enriched ecosystems.

Stack: when land is limited, but some of the five themes are demand, and there is a high level of space, integrate new technologies to optimize this. Accomplish this in a singular approach (i.e. vertical farming, water towers, energy storage towers, so on). However, also generate synergy among them. Stacking also means mixing and coupling themes (i.e. water tower collection with vertical farming with aquaponics, or waste bio-digester tower processes with energy production). These will come together as a means of optimizing space while ensuring self-sufficiency and a (Re) generative approach.

Hybrid: when land is extensive but protected, or comes with only punctuated opportunities Stacked and multifunctional strategies could work closely together.



Enrich nature, enrich ecosystems

Bringing together a fragmented landscape not only requires creating connection among the different natural systems, but also reinforcing the permeable and natural land.

The analysis accentuates the separation between north and south in lux+. This clearly illustrates two main trends: while in the north the protected green areas keep the urbanization at a minimum, the reality is that the mono-centric dependency on the south places a great demand on infrastructure. This has impact on the natural landscape, and in the long term promotes urbanization along the roads. The perpetuation of this dynamic will further fragment the natural landscape of lux+.

On the other hand, we see visible consequences of this pattern in the south, where the natural systems concentrate in rural land use in between large conurbations along roads.

The strategy must rebalance north and south, and in doing so to generate a more cohesive natural landscape, while at the same time promoting more equal access to and greater contact with nature in all settlement areas.

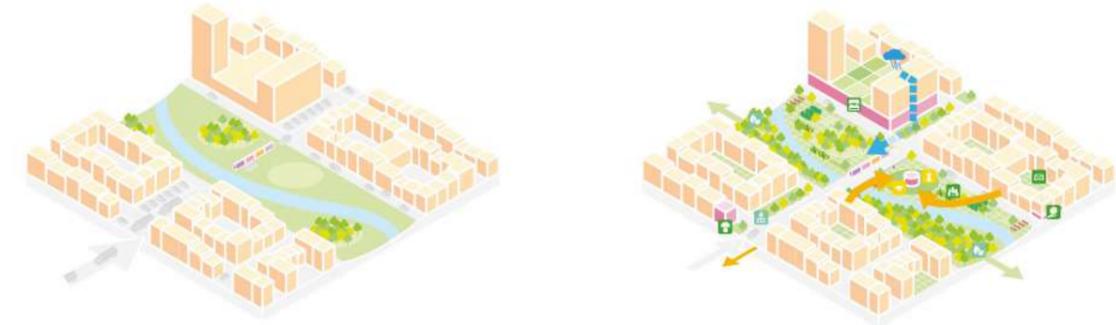
The following three transformation strategies support this:

From urban to nature: ensure the integration of more ecological corridors in large and medium cities. This requires specific care of re-purposing roads within cities, and ensures that buildings and the built environment becomes more permeable and more green. Following the potential strategy for settlements, some will adhere to the re-purpose principle. This will balance the proposal and avoid soil sealing, bringing balance, and generating a larger-scale re-naturalization of the region.

From urban to rural: transform vacant space in medium to large cities to rural, productive space to intensify. This contributes to soil quality and permeability in urban areas. In contrast, in small settlements with population shrinkage, re-purpose part of their space into rural activities and support settlements in the vicinity.

From rural to nature: if stacking, and adding multiple functions, incorporate natural environments. Localize ecological footprint production around urban settlements engaging the opportunity for re-purposing rural land into more natural and wild ecosystems.

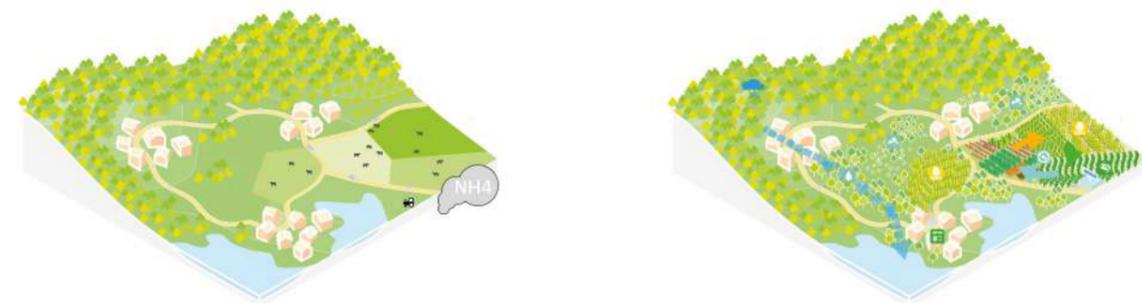
Urban to Nature



Rural to Nature



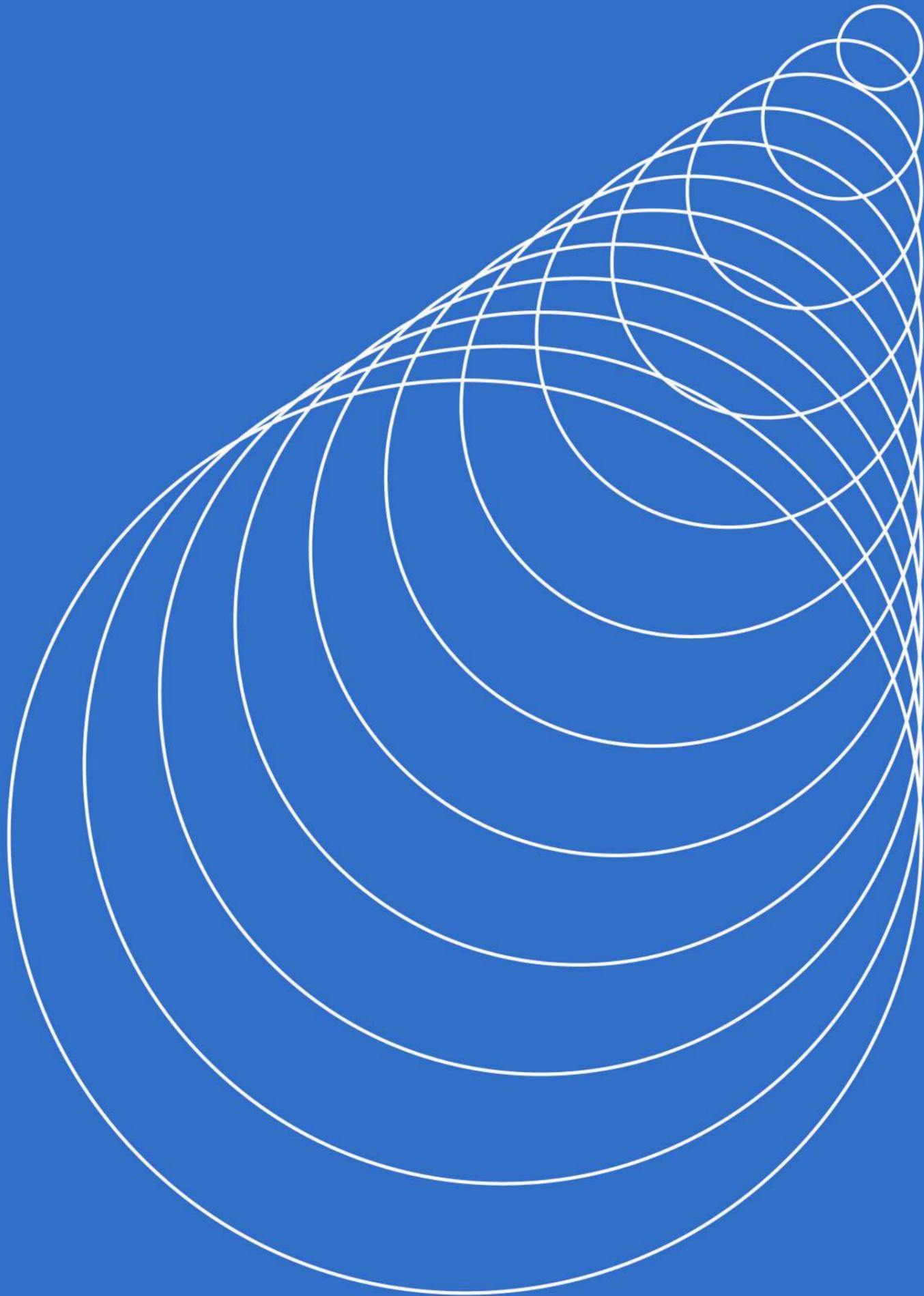
Urban to Rural

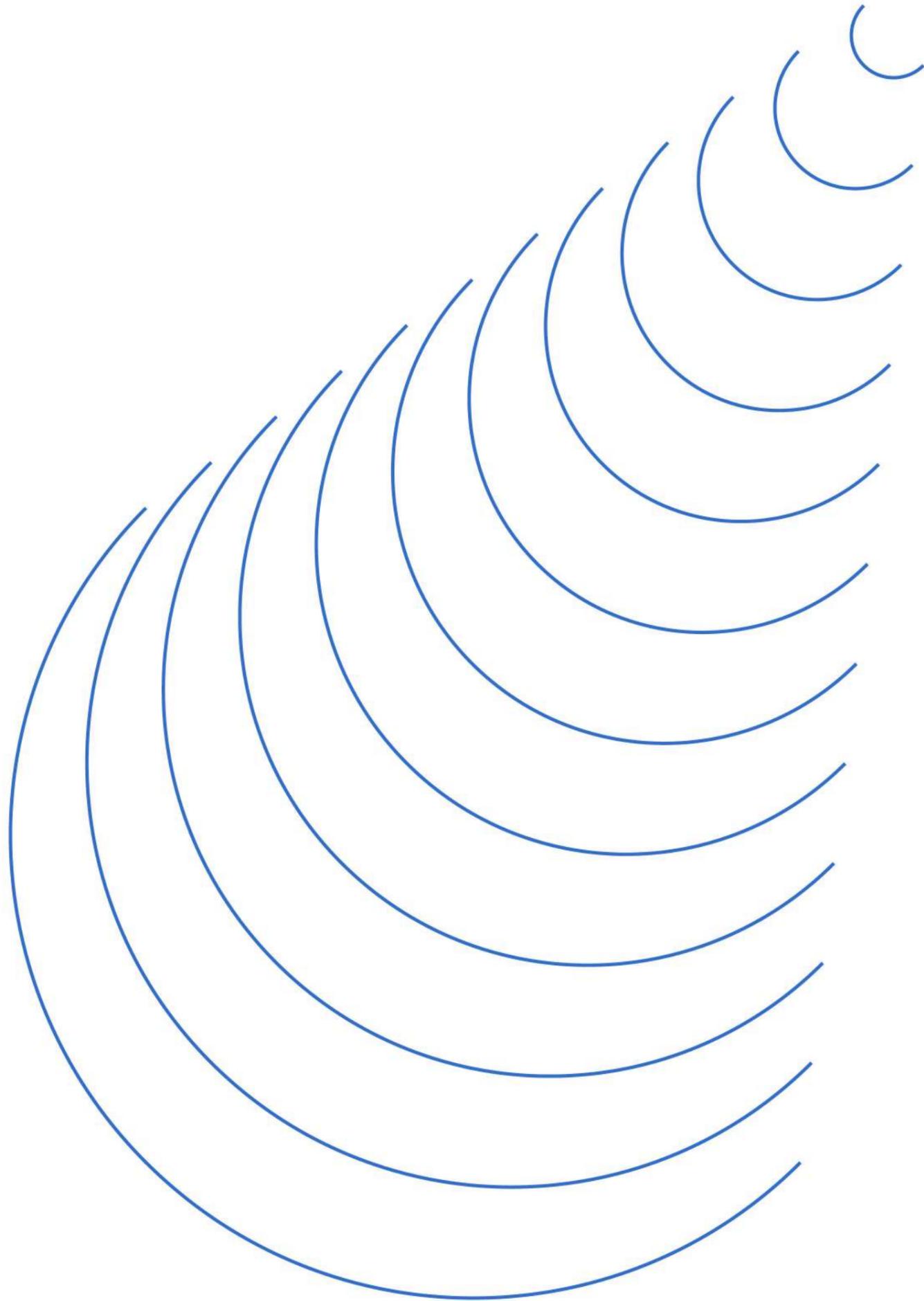


(re)generation matrix

(re)generation parameters
9 steps for change

3





(re)generation
parameters

Integrating the five themes

As presented in Phase 1, and mentioned previously, this process applies a linear methodology. Key themes highlighted in this are food, energy, mobility, water, and waste. Within these themes, we aim to reach a result beyond zero carbon: a state of regeneration. With increasing emphasis on regeneration - which is necessary if a balance is to be achieved - as a means of repairing damage which natural and social systems have endured.

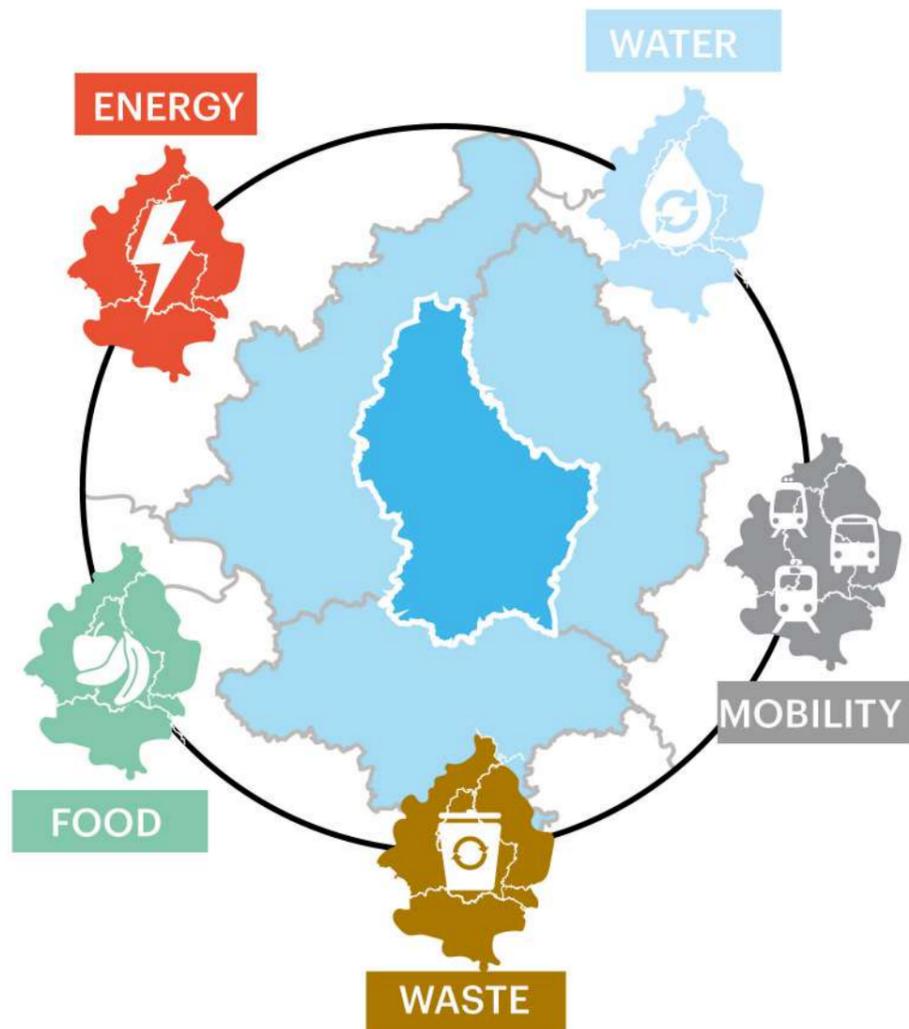
To achieve this balance, Luxemburgish and civil society organizations that are linked to both producers and to political systems in a complex web of relationships, must be addressed by the methodology. Sustainable consumption requires an integrated approach that includes individual consumption decisions, marketers' business policies, and high level supervision and monitoring.

Sustainable consumption implies the use of resources which can meet human needs and

increase the quality of life, while minimizing the use of natural resources, toxic materials, and emissions of waste and pollutants over the life cycle, to prevent the jeopardizing the needs of future generations.

Adding more recent concerns with respect to regeneration, sustainable consumption enables the restoration of damaged ecological and social fabric. It is thus apparent that sustainable consumption is not related to direct consumption only; instead, it covers the whole impact of purchasing patterns. While consumption directly affects environmental sustainability, purchasing behavior also affects it indirectly, via the production and marketing of commodities.

To achieve the desired state of regeneration, we propose an action matrix based on the five elements and three drivers. The drivers are sustainable consumption, local production enhancements and space optimization.



The three drivers



SUSTAINABLE CONSUMPTION (lifestyle change)

Guided by governance stimulus, that includes

- Tax incentives
- Health insurance discounts
- Incentives for local producers to offer healthier foods
- Monitoring food branding and marketing



STRENGTHEN LOCAL PRODUCTION (localizing consumption and production)

Guided by land use program

- Create a zoning strategy for food production areas in balance with each other.
- Support local farms to grow sustainably
- Create a campaign strategy to promote local produce
- Support the transition from industrial to local production



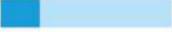
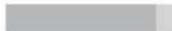
OPTIMIZATION OF SPACE

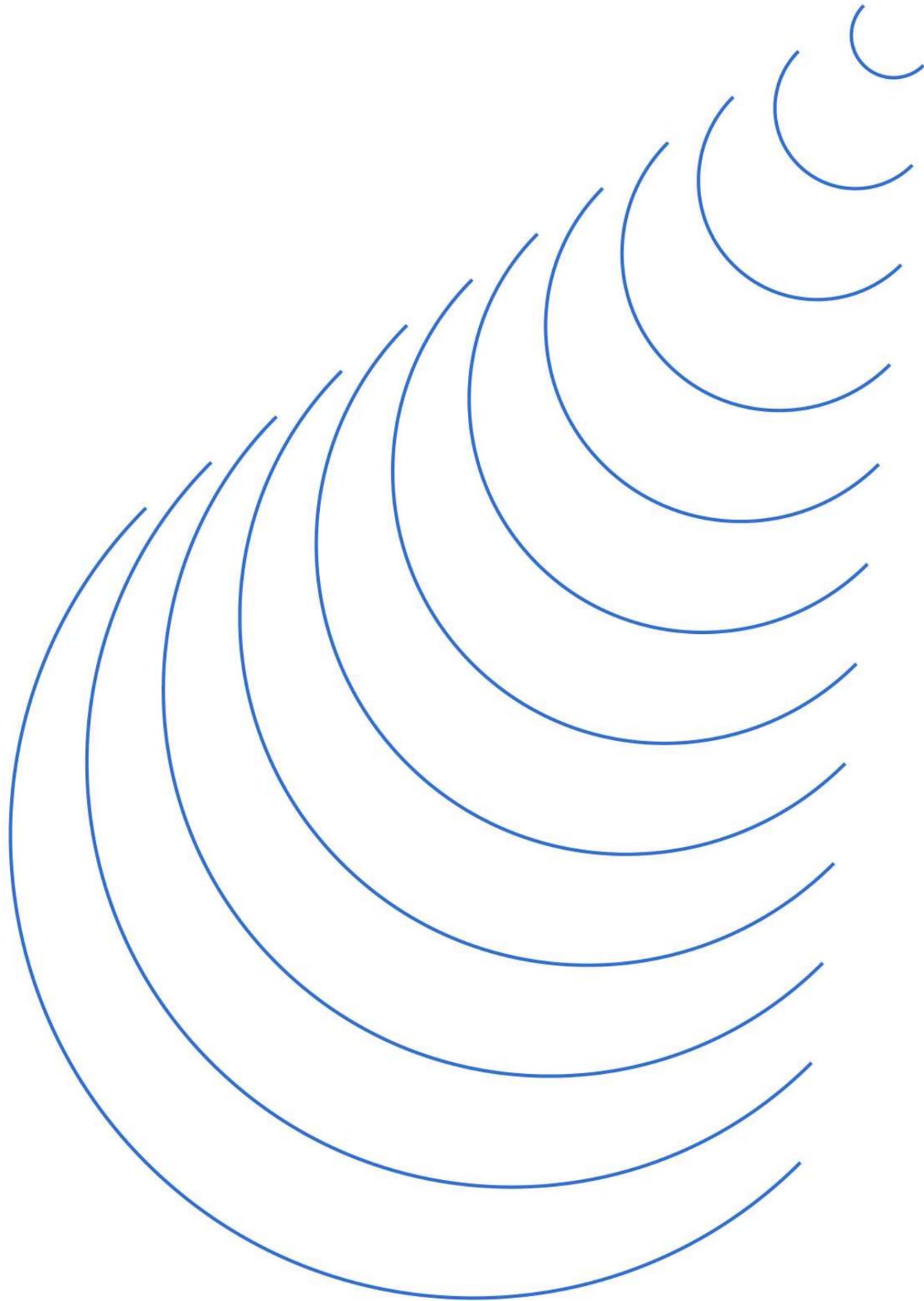
Guided by technology, innovation, synergies between systems, and overlapping techniques

Matrix of (re) generation

	SUSTAINABLE CONSUMPTION (lifestyle change)	STRENGTHEN LOCAL PRODUCTION (localizing consumption and production)	OPTIMIZATION OF SPACE
	Healthy plant-based diet, by eating less meat and adopt a seasonal diet	Short food-chain , by diversifying local supply	Conscient use of space for food production , by using agroecology & technology
	awareness and carbon tax to reduce energy consumption	Local clean energy production & storage	Enhance building performance by retrofitting old structures
	awareness and seasonal taxation to reduce water consumption	water re-use, decentralized water sourcing	Enhance water capture and sourcing by leveraging rain-water, renaturalizing and re-permeabilizing
	Switch to active and non-motorized modes	Short distances for movement of people and goods	Zero-emission mobility , by stimulating clean vehicles, public & shared transportation and by banning cars in city centres
	Eliminate household waste	Cease exporting waste by creating circularity hubs	Optimize waste management & sybiosis with nature by re-purposing landfills and brown fields

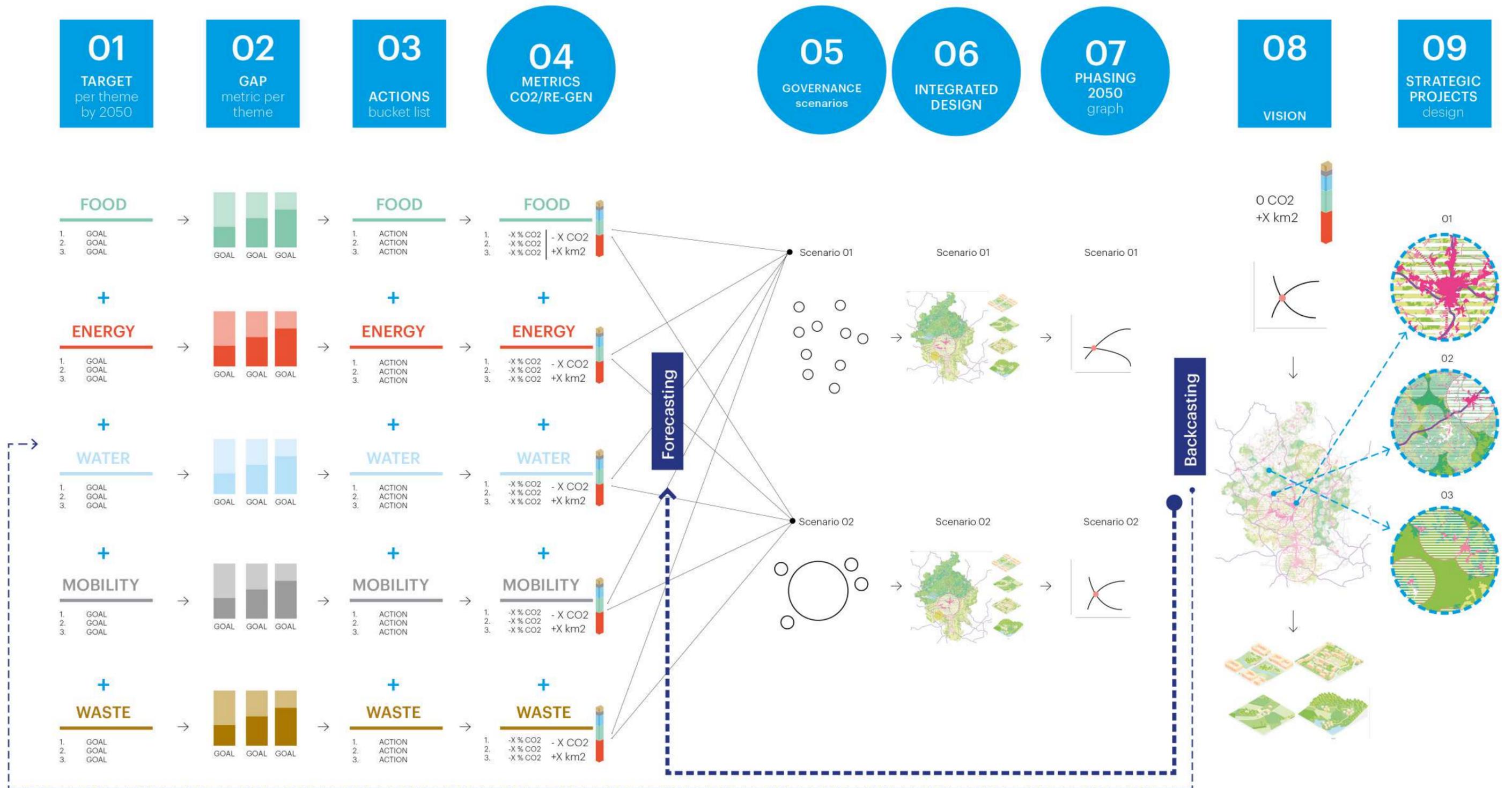
How much?

	SUSTAINABLE CONSUMPTION (lifestyle change)	STRENGTHEN LOCAL PRODUCTION (localizing consumption and production)	OPTIMIZATION OF SPACE
	 ?%	 ?%	 ?%
	 ?%	 ?%	 ?%
	 ?%	 ?%	 ?%
	 ?%	 ?%	 ?%
	 ?%	 ?%	 ?%



9 steps for
change

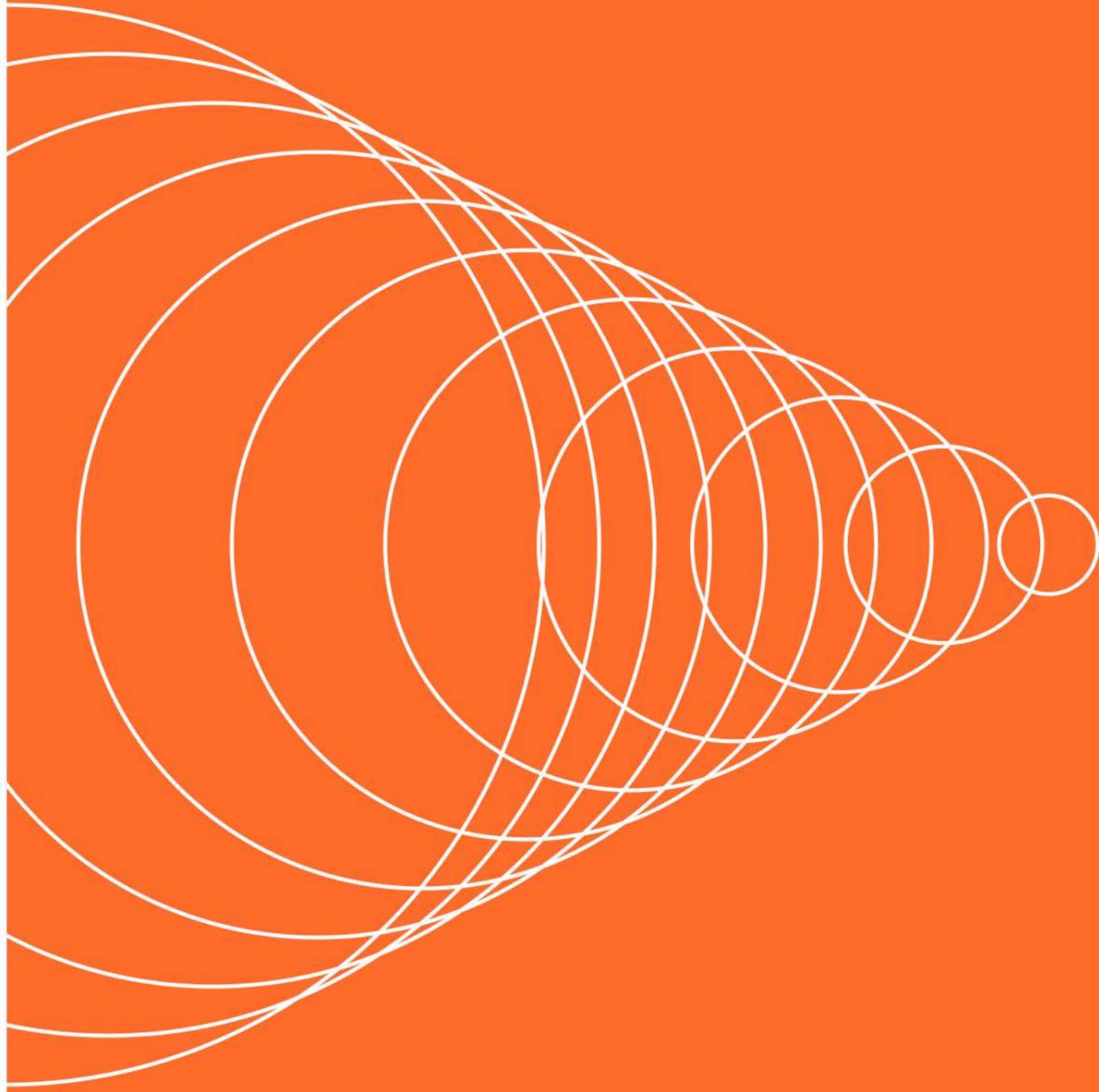
9 steps for change



Decarbonization tool

From target to metric per theme
Decarbonization tool
Testing the tool

4



01
TARGET
per theme
by 2050

02
GAP
metric per
theme

03
ACTIONS
bucket list

04
METRICS
CO2/RE-GEN

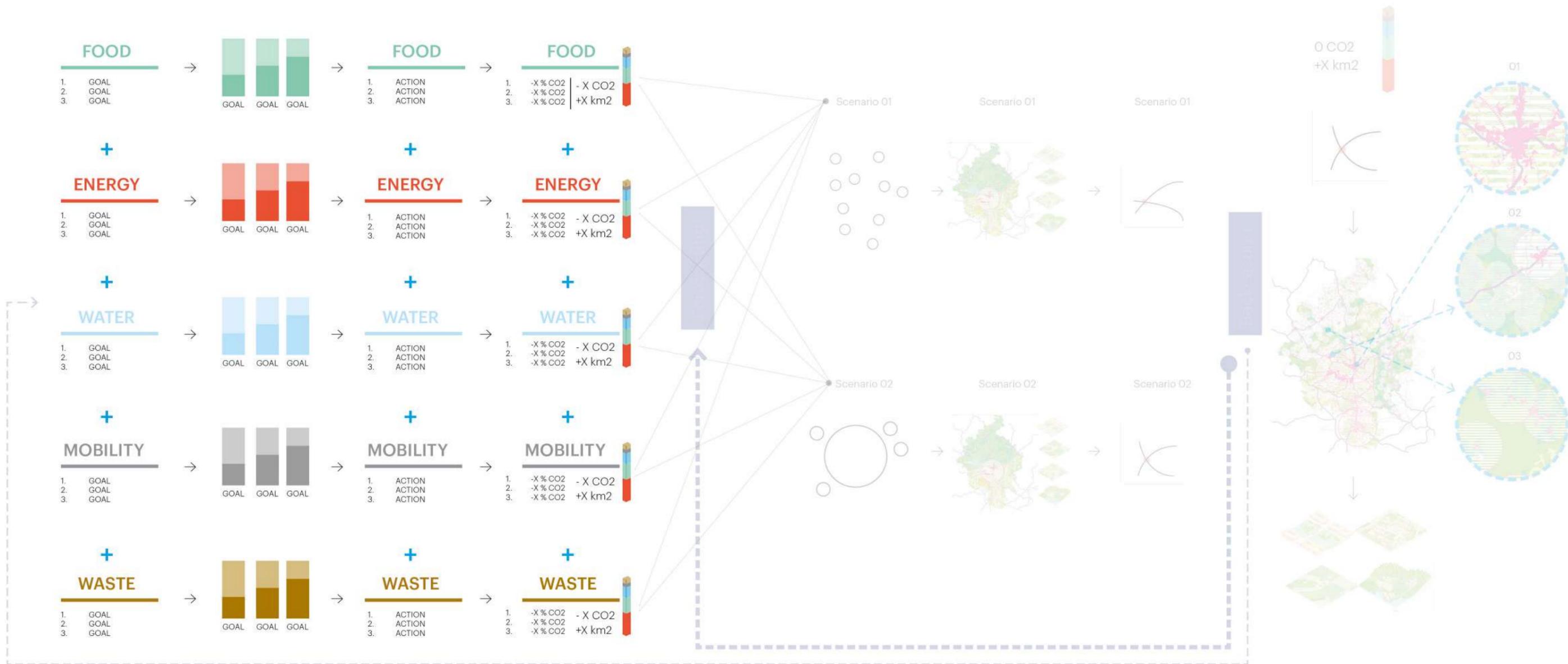
05
GOVERNANCE
CONTRACT

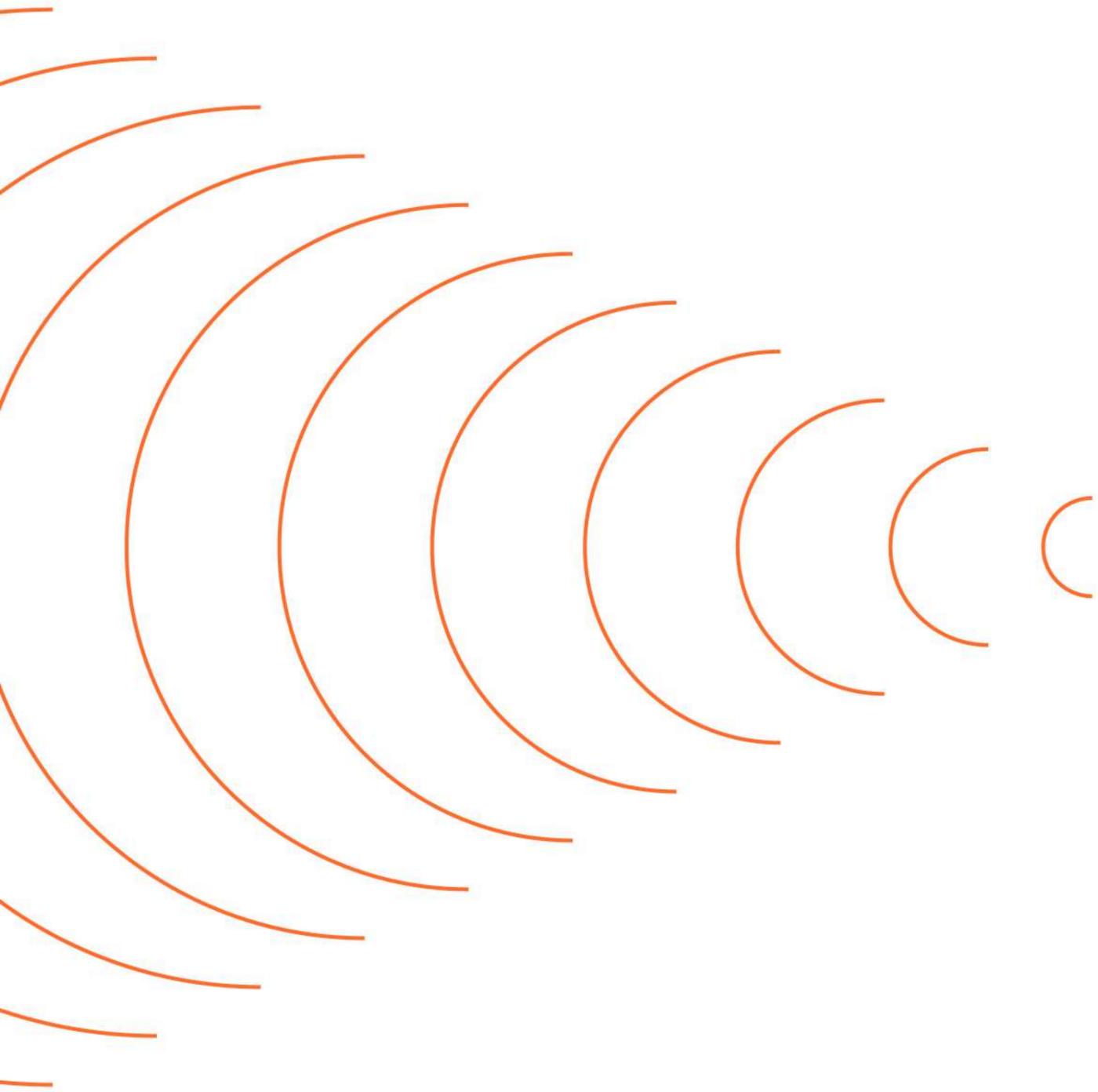
06
INTEGRATED
DESIGN

07
PHASING
2050
PLAN

08
VISION

09
STRATEGIC
PROJECTS
PLAN





From target
to metric
per theme

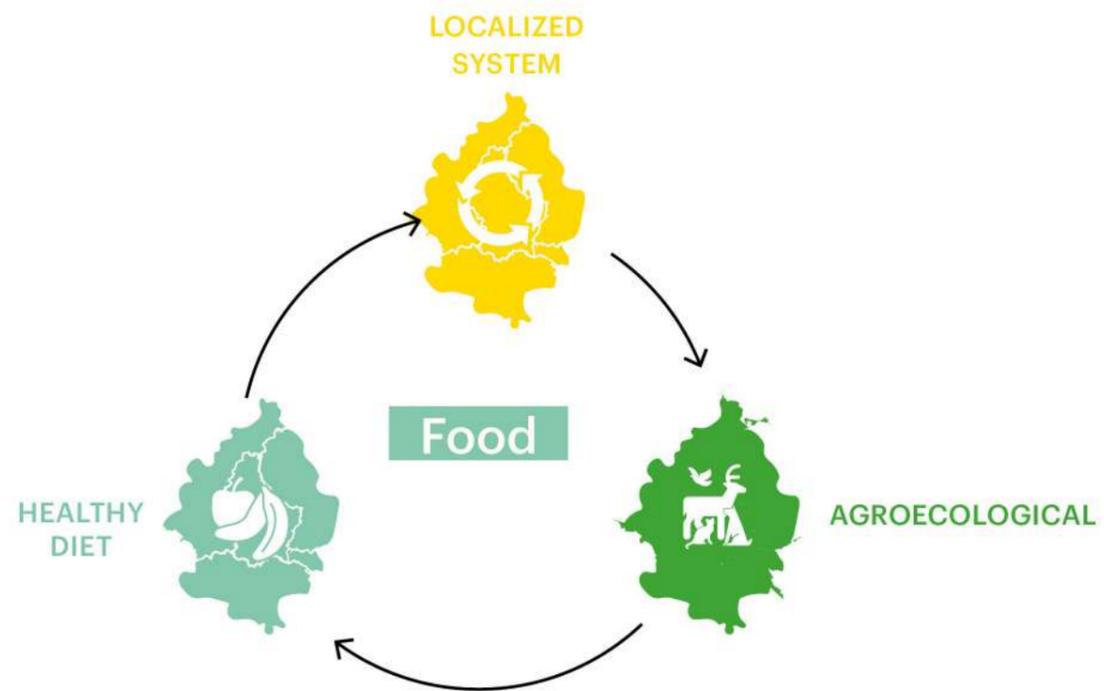
1. Target by 2050: FOOD

The explicit target is, for every theme: achieving a regenerative system by 2050 that contributes to all planetary systems through the generation and combination of sustainable, and resilient interventions, propeling a shift beyond mainstream zero carbon, circularity, and sustainability initiatives to forge systemic integration.

importing and exporting food from far away and establishing agroecological practices to replace agribusiness..

The regenerative target for food includes reductions that mean as much as xx% or the current CO2e in the Functional Area.

Actions include phasing out meat-lover habits, renaturate large part of the territory, reduce



2. The gap: how much % to get 100% (re)generative



3. Actions for (re) generation

HEALTHY PLANT-BASED DIET

Action #1 Incremental switch to plant-based diet

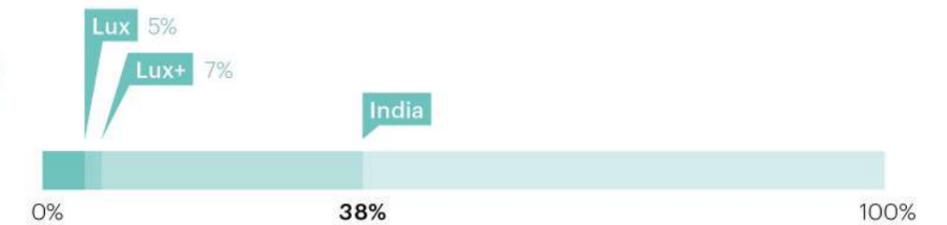
- Higher taxation of animal-based products
- Subsidize fresh, plant-based products
- Increase awareness about food chain and waste

Action #2 Reinterpret nutrition standards/labels

- Reinterpret nutrition pyramid and how we define healthy eating habits with minimized animal products
- Introduce alternative foods
- Introduce new parameters for what is edible and what is food waste
- Provide vegetarian-only meals in public institutions



% of vegetarian population⁽¹⁾



LOCALIZED FOOD PRODUCTION AND CONSUMPTION

Action #1 Diversify and Strengthen local supply

- Encourage mixed-type productivity
- Discourage importing/exporting of food products from the Functional Area (ecotaxes)

Action #2 Shorten the supply chain

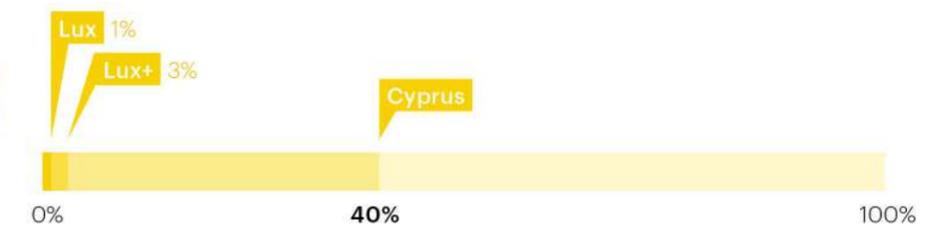
- Maximize urban agriculture
- Use organic waste for composting

Action #3 Re-purpose land use and productivity

- Rebalance land used for pasture/cattle and for productivity of fruits and vegetables
- Fix the urban fabric perimeter & redistribute growth
- Renaturalize farms, promote agroforestry practices
- Practice seasonal/ecosystem-specific production



% of agroforestry in agricultural land⁽²⁾



AGROECOLOGICAL

Action #1 Produce more in less space

- Implement precision agriculture
- Implement vertical farming and similar techniques for optimizing production

Action #2 Promote synergies between systems

- Introduce eco-corridors into farmland
- Locate farms close to industrial areas and mobility infrastructure and use their energy and heat surplus-

Action #3 Eliminate unsustainable practices

- Eliminate the use of chemical fertilizers
- Reduce food processing & packaging
- Switch from agro-industry to agroecology
- Use clean-energy machinery/tools



% of organic farming in total agricultural land⁽³⁾



(1) <https://www.worldatlas.com/articles/countries-with-the-highest-rates-of-vegetarianism.html>

(2) https://www.researchgate.net/figure/Total-extent-of-agroforestry-in-Europe-based-on-LUCAS-data_tbl2_315380865

(3) <https://ec.europa.eu/eurostat/web/products-eurostat-news/-/DDN-20190130-1>

1. Target by 2050: ENERGY

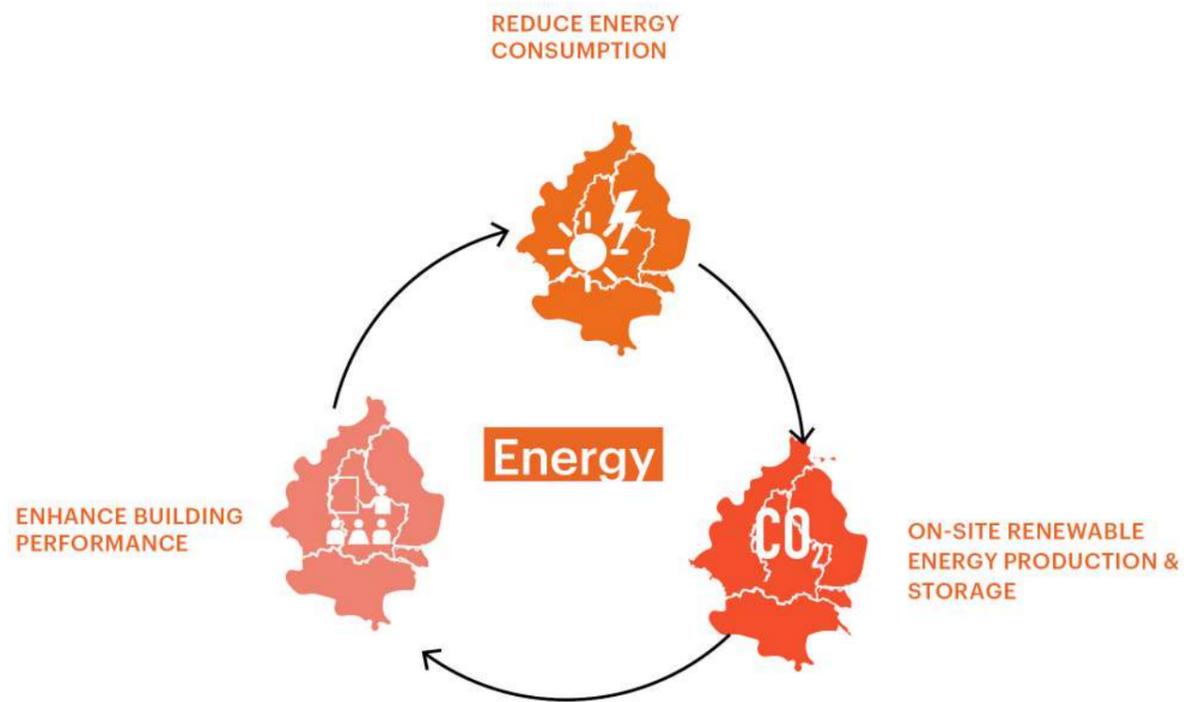
In the 2015 Paris Agreement, the international community established the shared objective to tackle global warming to a value 2 degrees below its current mark to the pre-industrial era, pursuing a maximum temperature increase of 1.5 degrees.

Due to significant climate change, it is logical to assume that the Luxembourg the country will adopt a clean strategy for energy supply, with high efficiency, and zero emissions.

A regenerative energy system is entirely based on renewable resources, combined with a solid on-site storage system, will ensure a high energy supply autonomy.

For this reason, the strategy pursues the following objectives:

- Energy consumption awareness and Reduction
- On-site renewable energy production and storage
- Enhanced building performance



Biomass, Luxembourg



Nuclear plant, Luxembourg



Wind Park Eifel, Germany



Solar farm in Saar-land, Germany

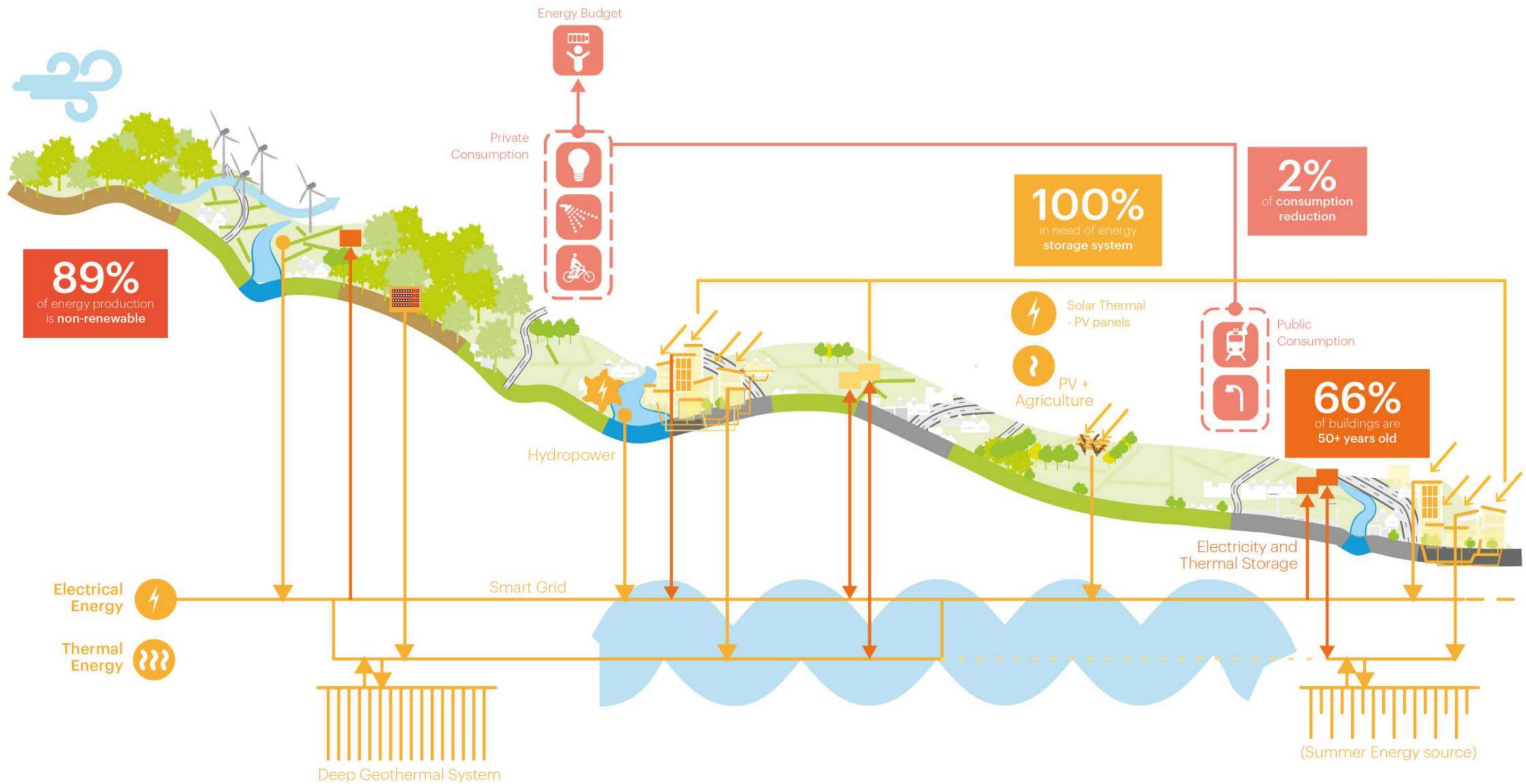


Pumped storage power plant Vianden, Luxembourg



Arzfeld, Germany

2. The gap: how much % to get 100% (re)generative



3. Actions for (re) generation

REDUCE ENERGY CONSUMPTION

Action#1 Define energy budget per capita

- Provide self monitoring app for personal simultaneous consumption and behaviour
- Spread information through media, educational programs and smart indicators
- Redefine comfort standards from to 29C + breeze

Action#2 Define maximum living area per capita

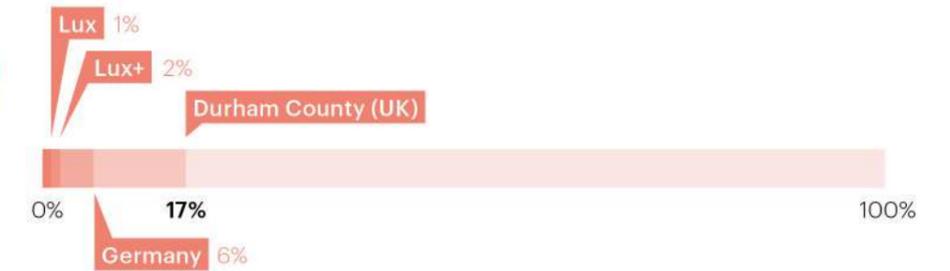
- Taxation for extra space
- Land use and zoning for strategic growth management

Action#3 Facilitate individual adoption of clean electricity

- Incentives for individualized clean electricity
- Incentives for electric vehicles



% of energy consumption change⁽¹⁾



LOCAL CLEAN ENERGY PRODUCTION & STORAGE

Action#1 Stop producing fossil fuel energy

- Taxation to discourage the production and use of gasoline & other fossil fuels

Action#2 Produce clean energy

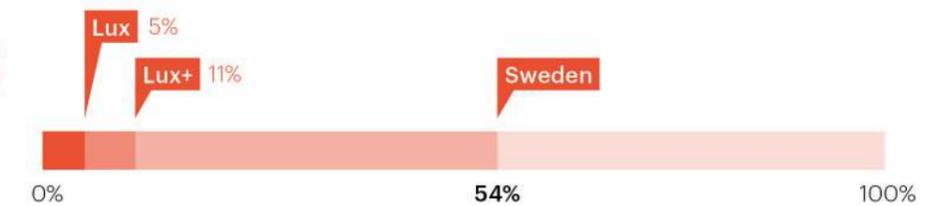
- Implement wind farms (Bastogne, Clevaux, Vianden, Diekirch), solar farms (Capellen, Esch-sur-Alzette, Arnon) and geothermal system (Esch-sur-Alzette, Thionville) to leverage local potential
- Implement an energy storage system for Electricity and Thermal energy

Action#3 Shared Ownership System

- Bonus for shared systems
- Smart energy grid
- Use block-chain technology for local energy trade



% of clean energy⁽²⁾



ENHANCE BUILDING PERFORMANCE

Action#1 Adapt buildings with non-optimal performance

- Requalification of "old" buildings for better energy performance

Action#2 Promote synergies between systems

- Enhance multi-productivity : agriculture + clean energy
- Employ a land use strategy: density + green for cooling
- Cogen systems (data centres, hospitals, schools, housing)



% of new buildings (<50 years)⁽³⁾



(1) https://www.interregeurope.eu/fileadmin/user_upload/plp_uploads/policy_briefs/PolicyBrief_Behavioural_Change.pdf
 (2) <https://ec.europa.eu/eurostat/documents/2995521/8612324/8-25012018-AP-EN.pdf/9cd28caef-1961-4dd1-a901-af18f121fb2d>
 (3) Andersson, D. E., & Andersson, Å. E. (2019). Sustainability and the Built Environment: The Role of Durability. Sustainability, 11(18), 4926.

1. Target by 2050: WATER

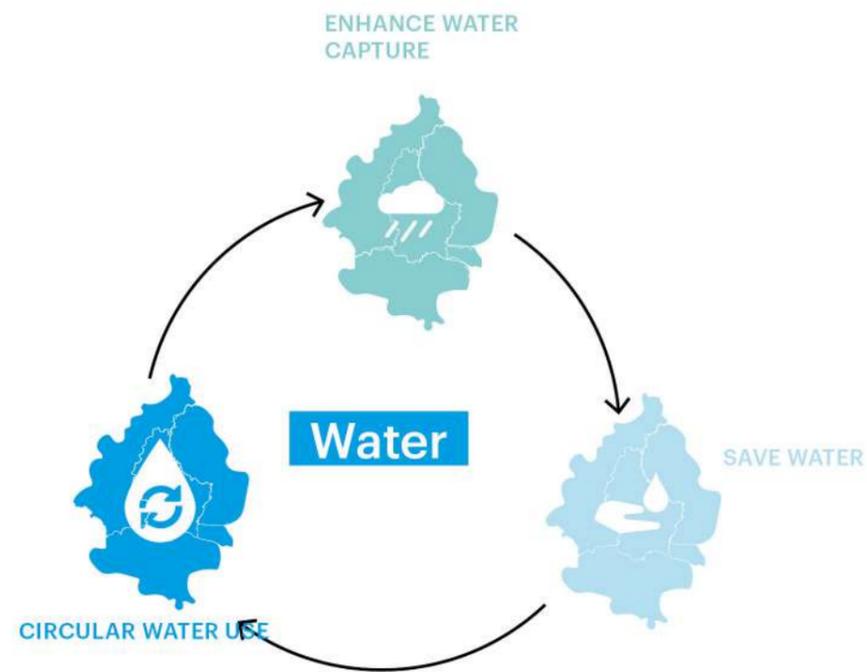
In order to obtain a sustainable water system, it is important to encourage the use of local sources to minimize over-extraction of certain sources and reduce the amount of energy required for transport.

Stimulating the infiltration of runoff to recharge aquifers and mitigate the negative trend of increasing fast drainage due to more intense precipitation peaks and soil sealing is also necessary.

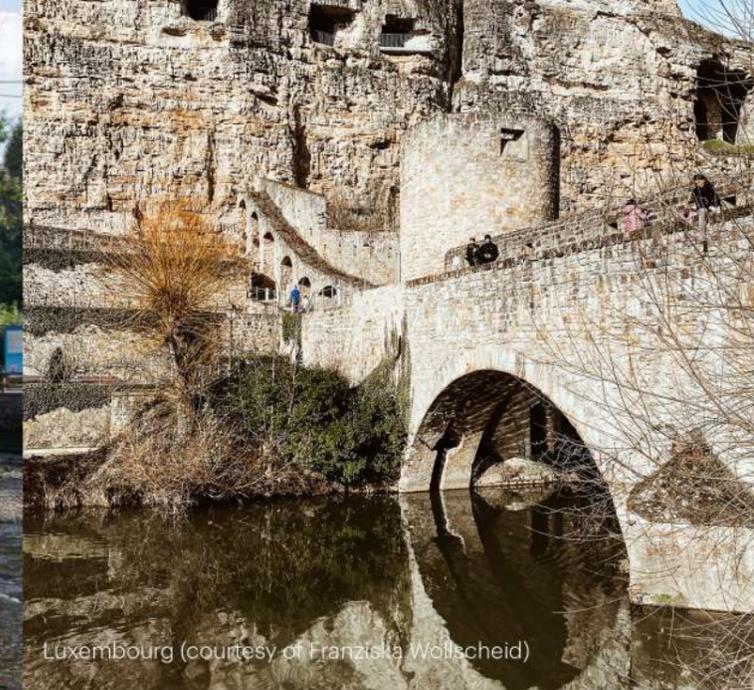
In parallel, it is crucial to reduce the negative anthropogenic influence on water quality and stimulate (natural) purification before infiltration or drainage.

Finally, it is critical that we achieve a balanced extraction of groundwater over the year. For this, excessive usage of water in summer should be discouraged and more efficient irrigation methods for (future) food production should be deployed

Reaching these goals should result in a water system that can absorb sudden shocks and be resilient over time.



Cascade de Coo, Ardenne, Belgium



Luxembourg (courtesy of Franziska Wollscheid)



Moselle river, Trier, Germany



Niklosberg, Luxembourg (North)

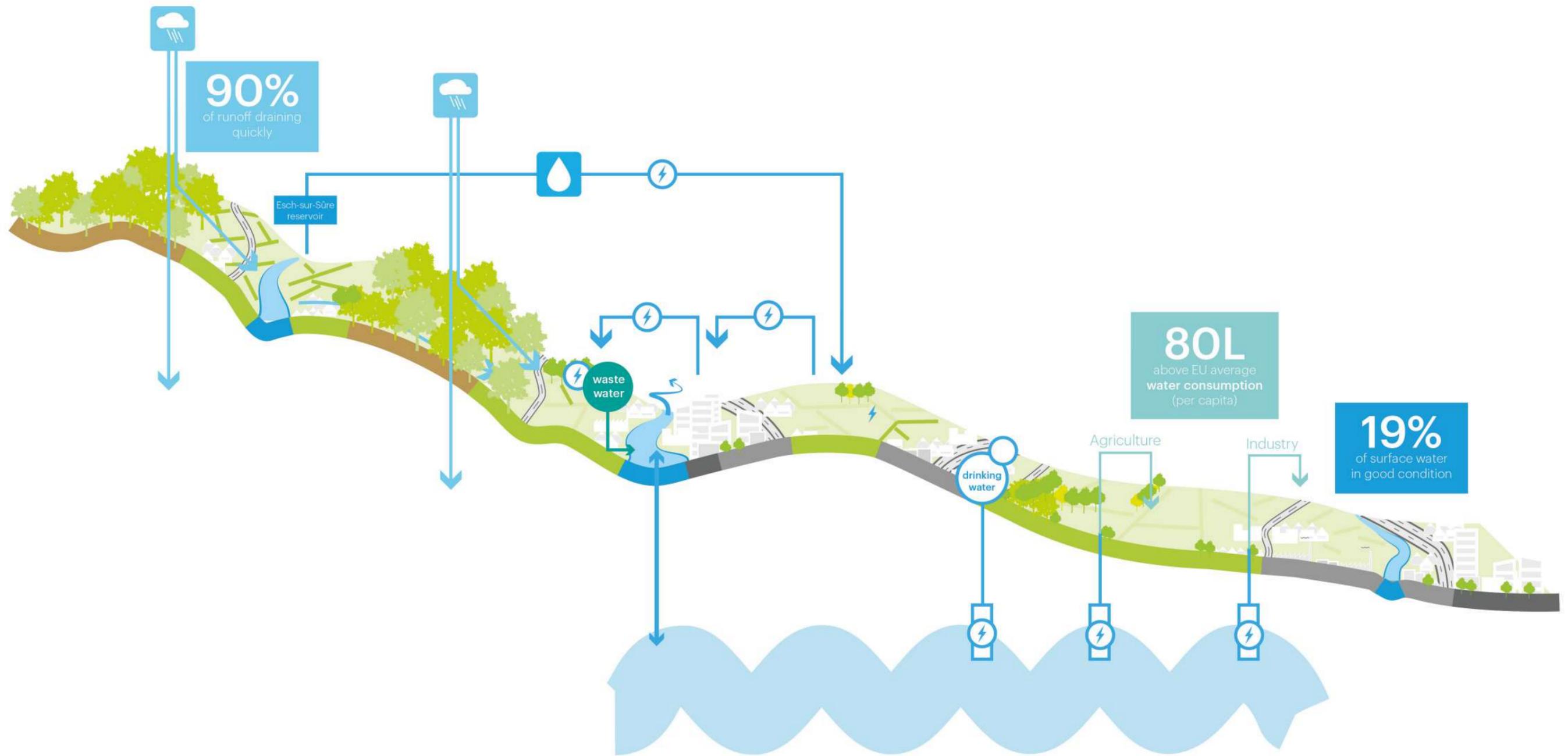


Remerschen, Scheffers, Luxembourg



Fisch-sur-Sûre, Luxembourg's main drinking water source

2. The gap: how much % to get 100% (re)generative



3. Actions for (re) generation

SAVE WATER

Action #1 Flexible consumption

- Seasonal fluctuation in water taxation
- Seasonal ban on high water consumption

Action #2 Sustainable gardens & agriculture

- Promote water friendly domestic gardens
- Redesign & adapt water friendly urban gardens
- Switch irrigation to drip systems

Action #3 Water Concient choices

- Wash with micro-plastic-free detergents
- Consume less water-demanding products such as meat and clothes
- Prohibit industries from using surface water for cooling

Action #1 Re-use building water

- Reuse drinking water instead of draining
- Reuse greywater for toilet flushing

Action #2 Re-use stormwater

- Retain water on private plots for local reuse (runoff from roofs and ground pavement)
- Separate wastewater and stormwater drain system

Action #3 Use wet soil full potential

- Use sludge to produce biogas
- Maintain high groundwater level in wetlands to avoid oxidation of organic material

Action #1 Capture & retain rain water

- Build infiltration facilities in places with good hydraulic conductivity
- Build small weirs in upstream portions
- Build bioswales to purify street runoff

Action #2 Renaturalize

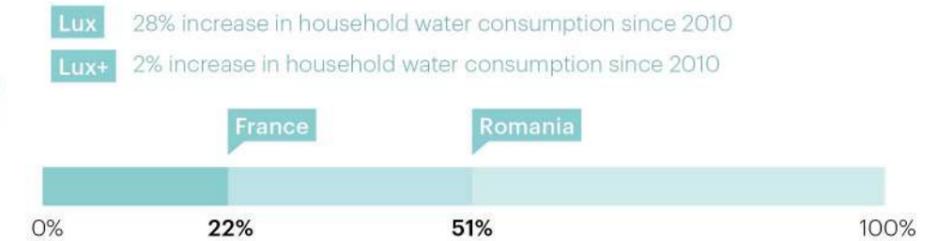
- Reconvert channelized streams
- Reintroduce meandering streams
- Build helophyte filters to purify open water bodies

Action #3 Repermeabilize

- Pave with permeable materials and techniques-



% of household water consumption reduction⁽¹⁾



CIRCULAR WATER USE



% of water reuse⁽²⁾



ENHANCE WATER CAPTURE



% of locally sourced water⁽³⁾



(1) Reynaud A. Modelling Household Water Demand in Europe - Insights from a Cross-Country Econometric Analysis of EU-28 countries. EUR 27310. Luxembourg (Luxembourg): Publications Office of the European Union; 2015. JRC96268

(2) Jones, Edward R; van Vliet, Michelle T H; Qadir, Manzoor; Bierkens, Marc F P (2020): Country-level and gridded wastewater production, collection, treatment and re-use. PANGAEA, <https://doi.org/10.1594/PANGAEA.918731>

(3) <https://www.waterfootprintassessmenttool.org/national-explorer/>

1. Target by 2050: WASTE

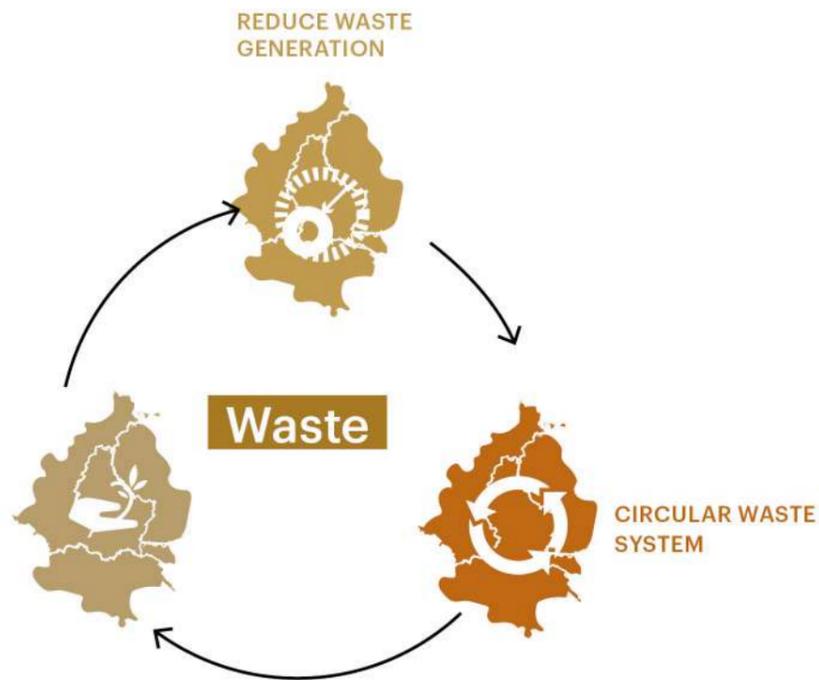
For a de-carbonized and resilient future of the Functional Area, we must reintroduce Waste into a material cycle that mirrors nature. At the border scale, the first step is to monitor performance and integrate information across borders. At the scale of each portion of the Functional area, different opportunities match the specificities of the geography and local context where it is inserted.

Prevention has to be the utmost goal for a (re)generative approach, followed by reuse and recycling, recovery, particularly energy and, last but not least, elimination.

Avoiding that a product becomes waste means re-educating the population about the harmfulness of waste, and enabling citizens to

take part in the challenge. The reintroduction of a product into the material cycle is the priority for a circular system, of no open-ended processes. Finally, disposal is reserved only for waste which is no longer suitable for an operation of reuse, recycling or generally energy recovery. On that case, disposal should be managed internally, not resorting to exporting waste to other sites out of the Functional Area.

Finally, re-purposing land used as dumping sites and utilizing the space for more eco-friendly or social purposes is also part of a (re)generative practice towards waste.



Waste collection in Luxembourg, SIECO



Waste separation in Luxembourg



Informal Landfill in Luxembourg



Waste Incineration Plant in Luxembourg

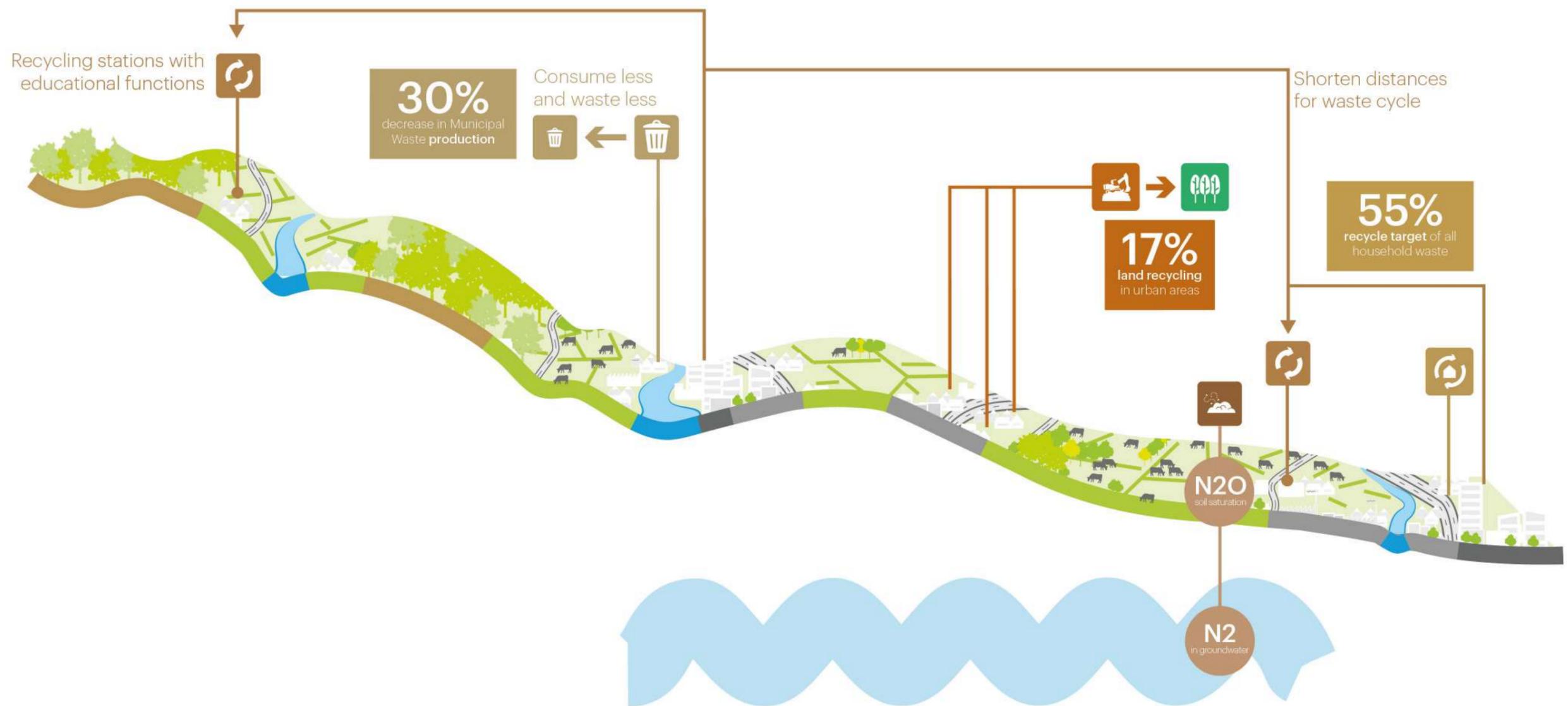


Decarbonization tool
Belgium land fill and recycling center



Beyond lux(e) - Stage 02
Thionville recycling center

2. The gap: how much % to get 100% (re)generative



3. Actions for (re) generation

REDUCE WASTE GENERATION

Action #1 Eliminate household waste

-Increase local recycling, especially wood and plastic

-Taxation on single-use plastic

Action #2 Eliminate household foodwaste

-Incentive individual composting in households

Action #3 Promote product as a service instead of product ownership

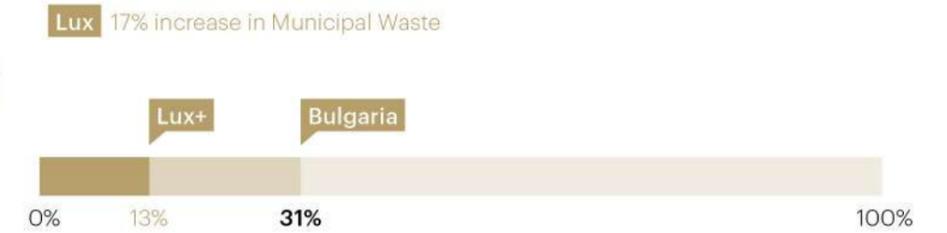
-Clothes as a service, shared closets

-Bike/trotinette as a service

-Mobility as a service



% of Municipal Waste reduction from 2005 - 2019⁽¹⁾



CIRCULAR WASTE SYSTEM

Action #1 Cease exporting waste

-Implement precision agriculture

Action #2 Establish recycle & upcycle hubs

-Implement circularity hubs close to trimodal hubs

-Incentive wood clusters

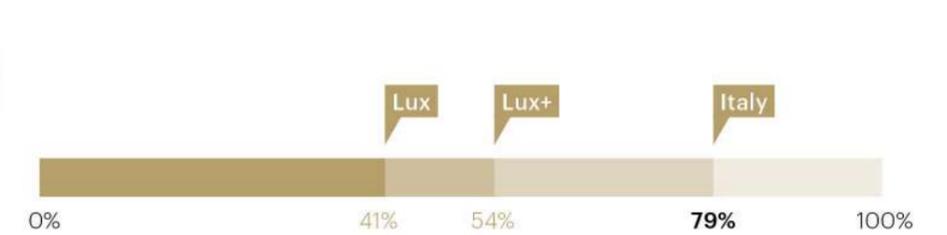
Action #3 Establish sustainable urban design and development practices

-Re-purpose inert waste from construction and demolition

-Practice net-zero land intake, minimize urban built-up area increase



% of waste recycled⁽²⁾



OPTIMIZE WASTE MANAGEMENT & SYMBIOSIS WITH NATURE

Action #1 Transform landfills

-Transform incineration plants into Syngas

-Transform landfills into parks

-Re-purpose brownfields for housing

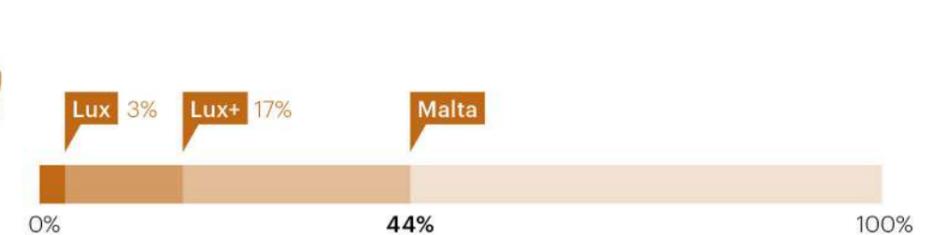
Action #2 Reduce Waste Transportation emissions

-Minimize exporting/importing of waste

-Install a pneumatic network for waste collection



% of land recycling in urban areas⁽³⁾



(1) https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Municipal_waste_statistics

(2) https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Waste_statistics#Waste_treatment

(3) <https://www.eea.europa.eu/publications/land-recycling-in-europe>

1. Target by 2050: MOBILITY

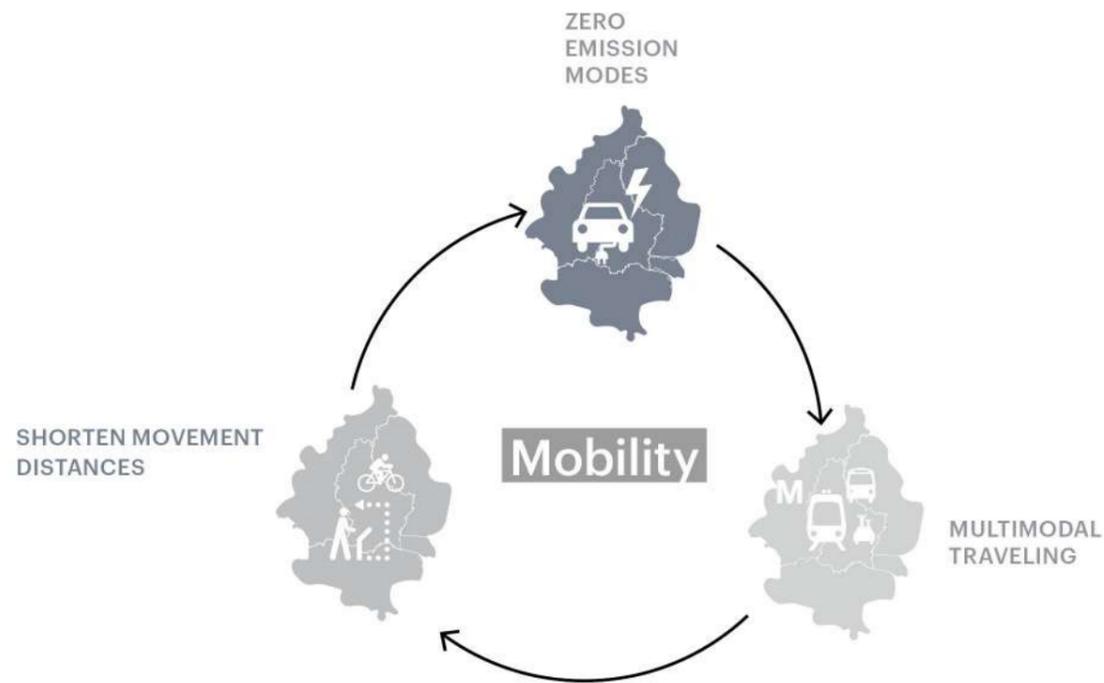
In the strategy, we investigate how the transport and land-use system functions in Luxembourg's functional area, and where opportunities lie for improvement.

The target is to become:

- more attractive (indicators: children walking to school, quality of public space);
- cleaner / more environment-friendly (indicators: use of sustainable modes, zero emission, energy consumption, small particles);
- more inclusive (indicators: cost of travel, access to opportunities);
- safer and healthier (indicators: road accidents,

air pollution, noise, use of active modes).

The current paradigm of improving transport systems focuses on increasing capacity and increasing the speed. However, this focus does not contribute to the goals mentioned above. We must shift towards the target goals. A key factor in this is accessibility, which can be achieved by making better connections for everyone and by improving proximity and intensification (bringing functions/amenities/opportunities closer)..



Traffic in Thionville-Luxembourg A31 highway



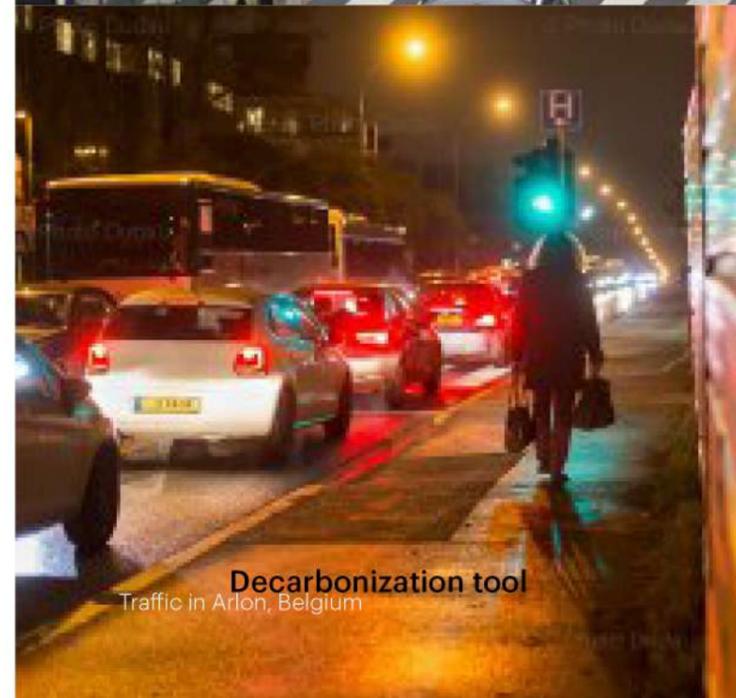
Traffic Accident in A31



Luxembourg City Traffic



Road in Clervaux, Luxembourg

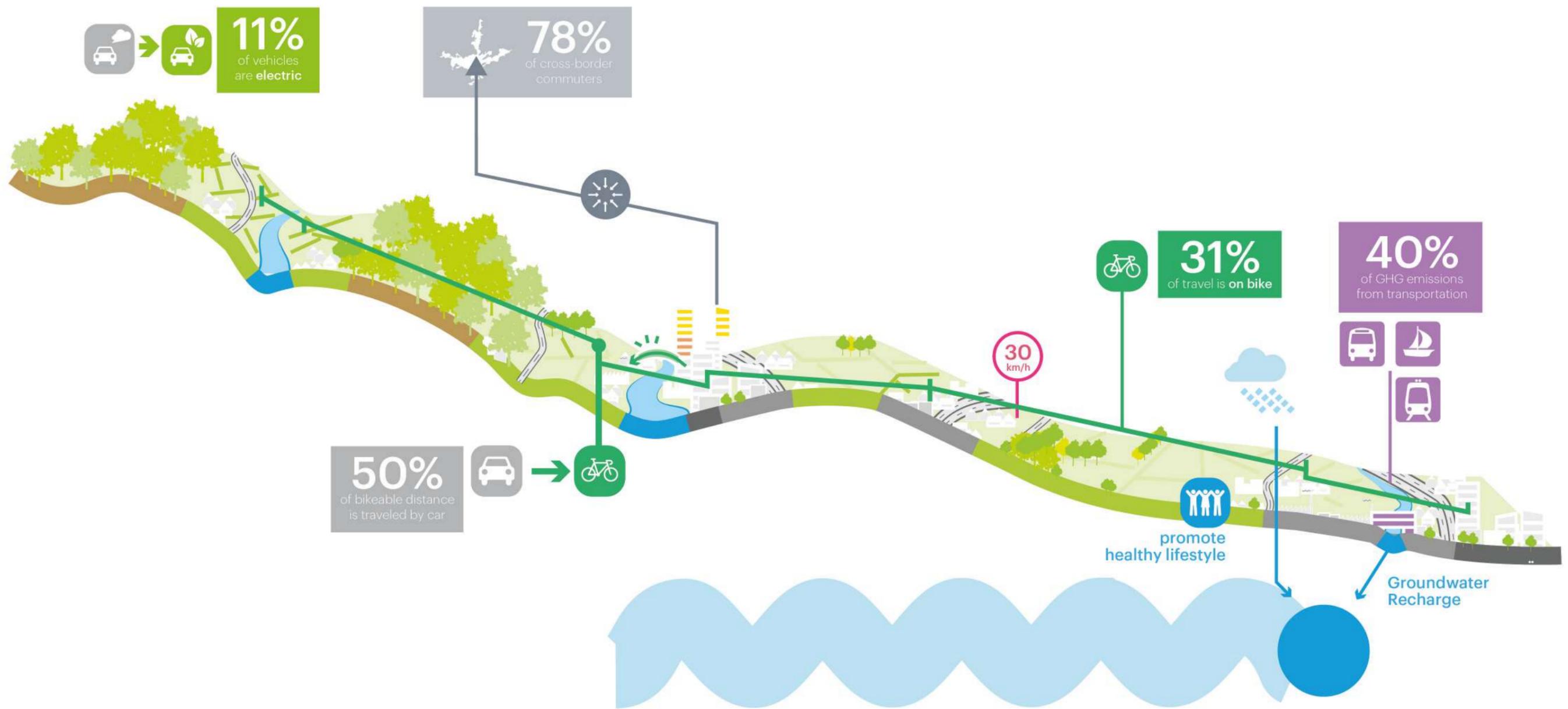


Decarbonization tool
Traffic in Arlon, Belgium



131 Beyond lux(e) - Stage O2
Ravel velo Bastogne

2. The gap: how much % to get 100% (re)generative



3. Actions for (re) generation

MULTIMODAL TRAVELING

- Action #1 Adopt active, non-motorized modes**
- Campaigning to stimulate taking short trips by walking or biking instead of car
 - Traffic education to prioritize soft modes
 - Create a Vision Zero plan to indicate policy and physical interventions in streetscape and public space to favour safety of pedestrians and bikers
- Action #2 Switch to shared mobility and MaaS**
- Discourage single occupancy car travel
 - Increase taxation in fossil fuels in the entire functional area
 - Provide e-services and smart mobility apps and infrastructure
- Action #3 Conscious consumption**
- Promote awareness to discourage importing



% of walking/biking to destinations⁽¹⁾



SHORTEN MOVEMENT DISTANCES

- Action #1 Promote land use-mix**
- Decentralize the provision of services, amenities, job opportunities and infrastructure to strengthen multiple nodes
 - Empower local initiatives and businesses in towns and villages
- Action #2 Reduce number of trips required**
- Incentivize remote working and flexible schedules
 - Support pilot projects for autonomous vehicles and innovative mobility alternatives that allow work/sleep/leisure while travelling
 - Improve coverage of transportation hubs for both freight and passenger



% of people usually working from home⁽²⁾



ZERO EMISSION MODES

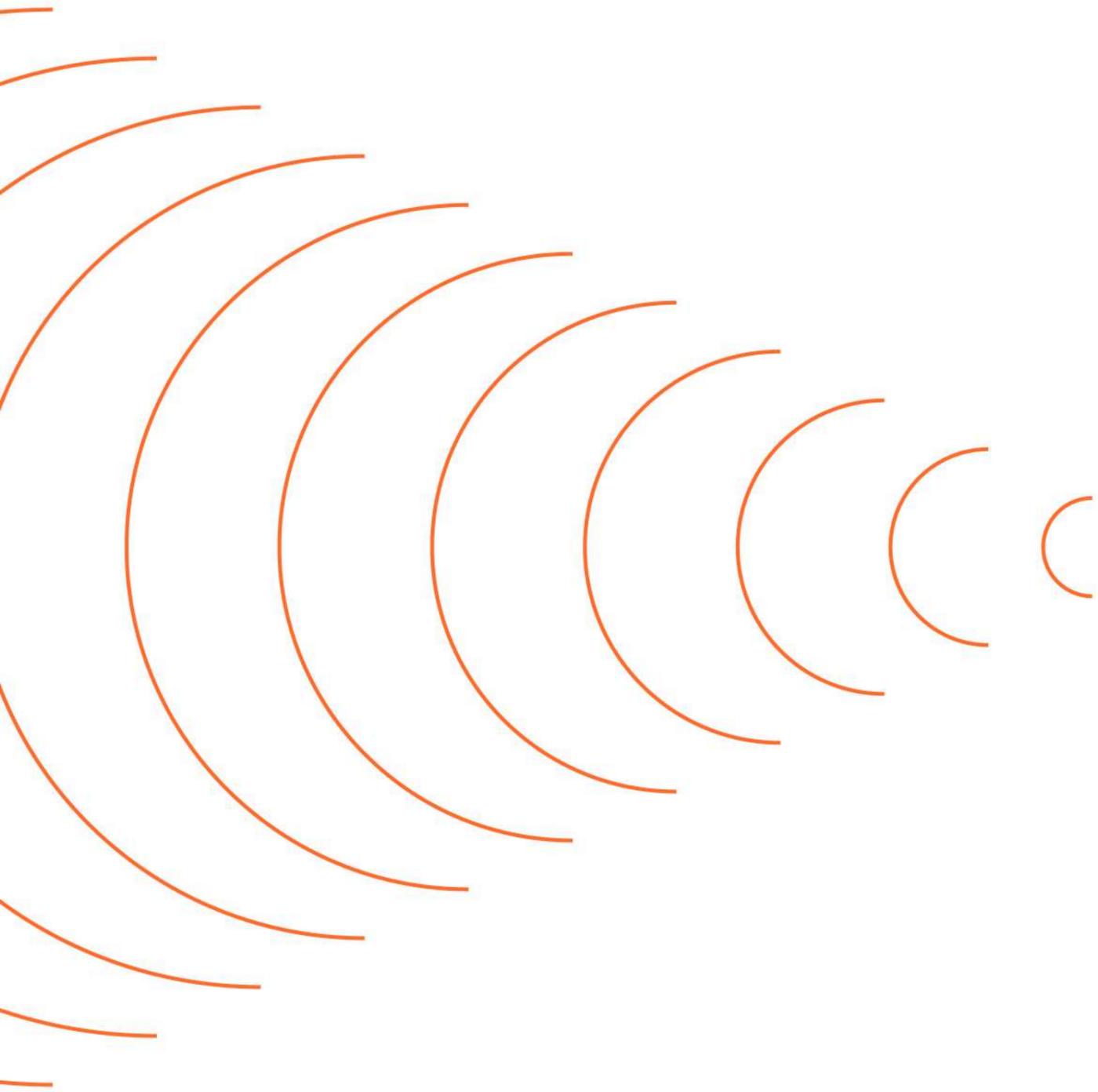
- Action #1 Switch to clean modes**
- Equalitarian taxation to discourage fossil fuels across the Functional area
 - Incentivize clean vehicle purchase and install solar panels to power them with clean energy on site
- Action #2 Stimulate multimodal mobility**
- Improve public transportation services and coverage
 - Improve smart infrastructure for mobility and apps
- Action #3 Zoning for car-ban and speed limit**
- Demarcate areas for non-motorized and soft mobility
 - Improve bike infrastructure for continuous, attractive and safe cross-border travel at 7,5km ranges
 - Deploy transfers between zones with multiple Park&Ride structures



% of electric vehicle⁽³⁾



(1) <https://www.smartcitiesdive.com/ex/sustainablecitiescollective/natgeo-surveys-countries%E2%80%99-transit-use-guess-who-comes-last/9081/>
 (2) <https://ec.europa.eu/eurostat/web/products-eurostat-news/-/DDN-20200424-1>
 (3) <https://www.weforum.org/agenda/2021/02/electric-vehicles-europe-percentage-sales/>



De- carbonization tool

The Decarbonization Tool

On Stage 2 of Luxembourg in Transition, we developed a tool to help us understand how each of the Actions we aim to implement could help the Functional Area to Achieve Zero Carbon by 2050.

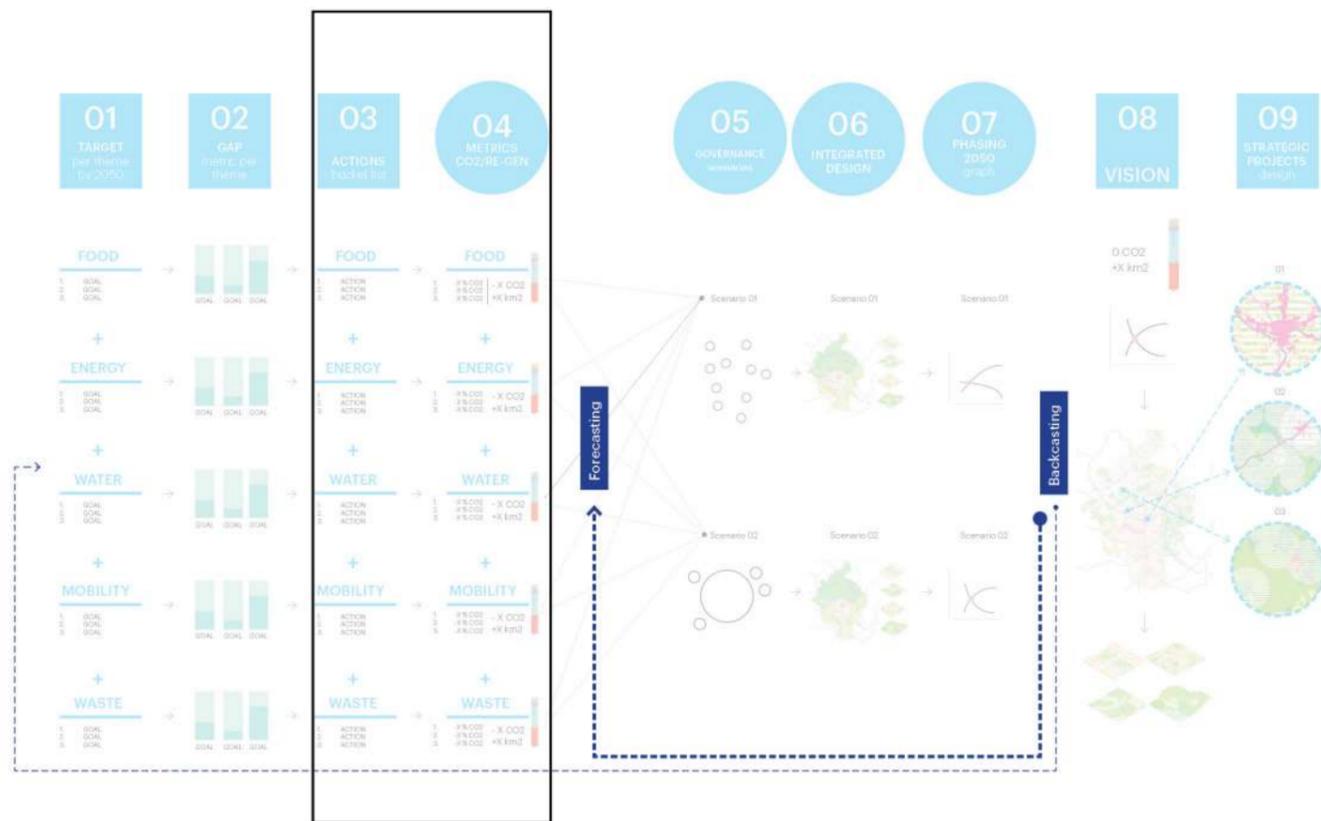
To understand how to use our Decarbonization tool, it is important to refer to the Methodology we adopt on our investigations.

We have a 9 step methodology that proposes Actions to be taken in every study theme (Energy, Water, Food, Mobility and Waste), and quantifies the contribution of those Actions in the Zero Carbon goal.

The Actions are guided by three (re)generative principles, for all themes:

- Lifestyle;
- Localizing production and consumption;
- Optimizig the system's efficiency through technologies or strategic mechanisms

We understand that each of these principles contribute, on their own way, to the the decarbonization objective. Depending on the governance approach adopted by the Functional Area administrators, it is possible to emphasize one or another principle. This way, one can implement measues to push for a specific principle with more urgency, and adjust the pace of change.



Decarbonization tool

The Starting point

We have started from the assumption that there are 2 million people in the Functional Area. Based on the growth per canton, we estimate that the population will increase, up to 2.2 million in 2050. On average, we assume a 14% growth to support the studies with our Decarbonization Tool.

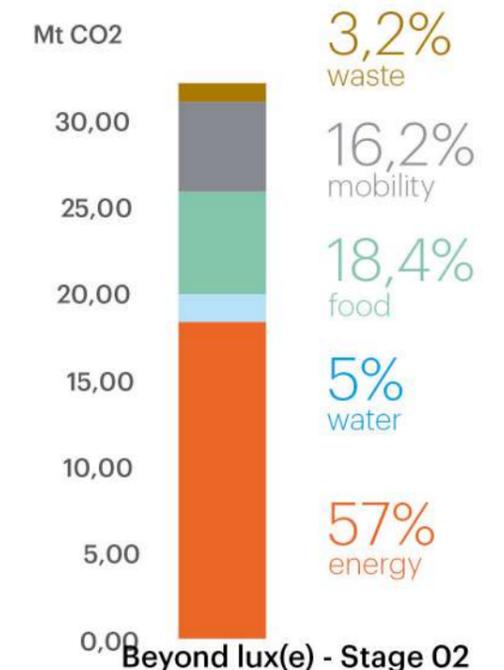
2 million

Population 2020



Carbon footprint estimate (Mt CO2 eq.)

Also as a starting point, we have assumed that the Functional Area currently emits, per year, 32 Mt CO2.



To understand what share of that corresponds to the sectors we study (Energy, Water, Food, Waste and Mobility), we assumed a direct correlation with the global GHG emission breakdown per sector.

Decarbonization tool

An overview of the Tool

Driver Principles

	LIFESTYLE CHANGE 1st step: GOVERNANCE	OPTIMIZED EFFICIENCY 2nd step: optimize	LOCALIZED SYSTEM 3rd step: localize
Rate of Change in	Behaviour	Optimization// Efficiency	Localized System
Energy	90%	30%	75%
Water	85%	40%	85%
Food	80%	30%	85%
Mobility	90%	35%	85%
Waste	85%	50%	85%

It is possible to propose that each theme adopts different change goals per driver principle. On the example above, we tested the impact of

changing the lifestyle of Food consumption in 90%, but only considered 30% of increase in optimization on the energy system.

The metrics summary per principle & per theme

Food	LIFESTYLE CHANGE	LOCALIZED	OPTIMIZED: Agroecology		
Measure	Healthy and plant based	Food trade reduction	(1) pasture to forest	(2) arable land to forest	(3) non-organic to organic
Slider	80%	85%	30%	30%	30%
Current CO2 Emission			5.9		
CO2 Reduction (MtCO2eq)	0.5	-0.1	1.5		
Spatial Demand (km ²)	7258			10354	

The Driver Principles determine how much weight certain action receives. In the Metric Summary table, it is possible to quickly visualize

how much CO2 reduction and how much spacial requirement reduction is achieved (Calculations in the Detailed Action table)

The Detailed Actions per principle & per theme

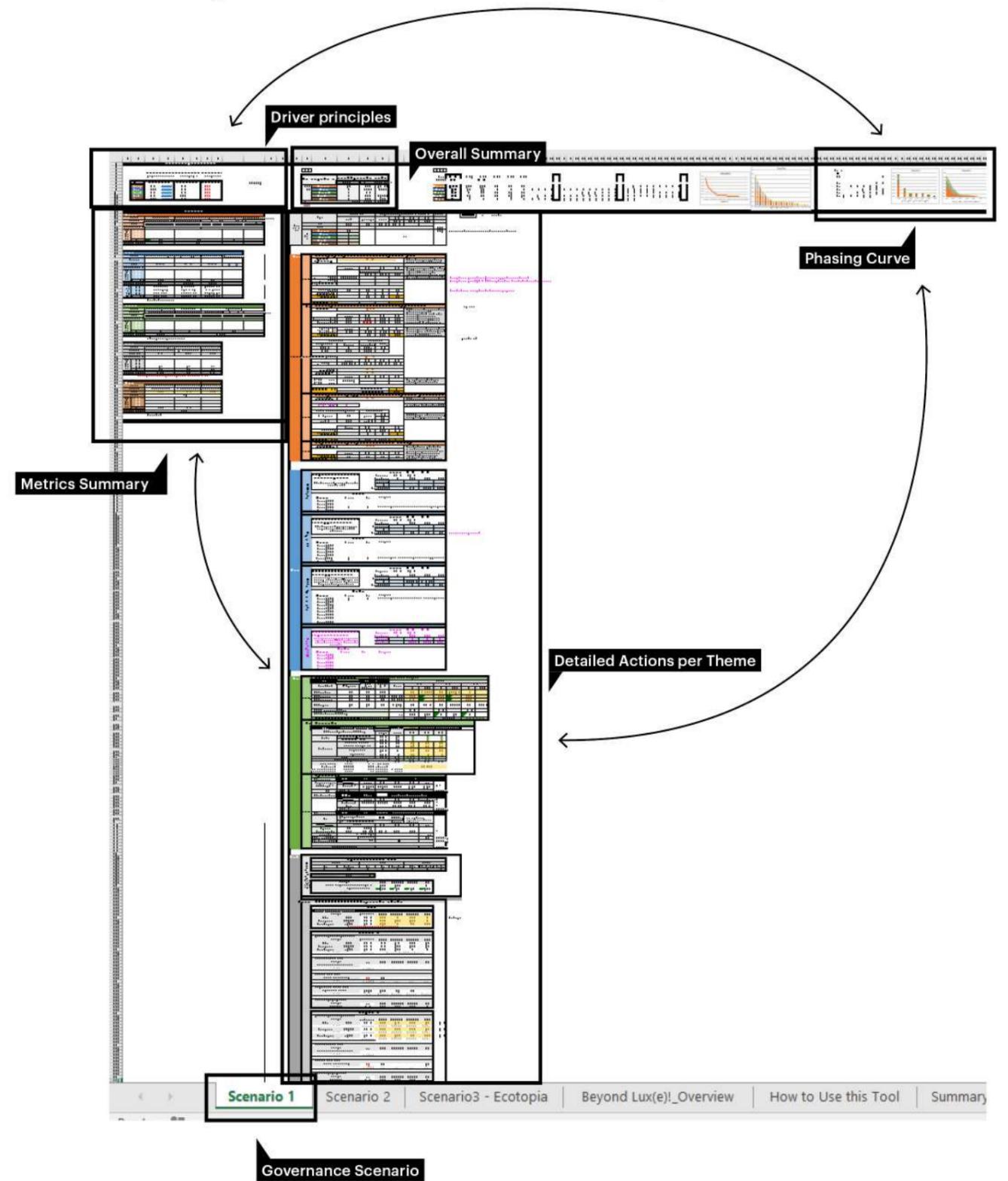
Food	Change food habits: documented shift in food consumption patterns				Flare			
	Slider	Required land (ha2/percentage)	CO2 Emission (MtCO2eq/percentage)	Distribution (100%)	Current	2050	2040	2050
(ME) Meat Eater	0.0096	2.9	75%	4,363,001	10%	3,243,370	20%	1,700,000
(FV) Flexitarian	0.0046	1.9	10%	666,056	20%	1,111,059	42%	1,740,553
(V0) Vegetarian	0.0014	1.7	5%	170,511	10%	335,016	29%	1,072,660
(VV) Vegan	0.0003	1.5	2%	60,181	2%	63,008	2%	65,837
CO2 Emission per year (MtCO2eq/yr)				5,279,837	new	5,055,323	new	4,623,472
CO2 Reduction (MtCO2eq/yr)				n/a	4%	0.21	0%	0.44
(2) Adjust burden on the food habits change:		(changing spatial demand (km ²))		16,236,00		14,230,44		10,846,77
								7,258,43
LOCAL SYSTEM	Local food system				Flare			
	Slider	Reduce import and export by	0%	each year	0%	is redistributed to the domestic production (arable land)		
	CO2 in food production (MtCO2eq)	capex/yr	current (yr)	2050	2040	2050		
	Trade	International transportation	5,42E-08	0.13	0.00	0.00	0.00	
		Trade emission	2,953E-07	0.57	0.00	0.00	0.00	
	Production	Exotic fermentation	2,354E-07	0.47	2.67	1.02	1.06	
		Mastern management	2,354E-07	0.47	2.67	1.02	1.06	
		Inorganic fertilizer	1,439E-07	0.30	1.70	0.63	0.63	
		Organic fertilizer	3,21E-08	0.06	0.36	0.14	0.15	
		Total	1,0025E-06	2.01	7.43	2.83	2.93	
CO2 Reduction (MtCO2eq/yr)			n/a	-5.41	4.33	-0.10		
Lessenbourg	2506	100% (arable/total)	11,638,31	2050	2040	2050		
Arable land	49,34	ha	2,826,23	1,918,36	1,304,85	363,40		
Pressure/land/ha	1829	mt	3,011,87	1,475,62	1,022,07	1,022,07		
Non-arable/land/ha	14.8	mt	78,54	533,51	415,46	415,46		
Agricultural land	1213.84	ha	5,315,35	6,950,65	8,339,26	10,255,95	c Total spatial demand	
OPTIMIZED	Agroecology				Flare			
	Slider	Shifting	30,00%	of pasture to forest each year				
	Capex capacity (MtCO2eq / ha ²)	current	2050	2040	2050	total		
	0.00038	0.011,87	2,108,31	1,475,62	1,022,07	1,022,07		
	CO2 reduction	0	0,34	0,59	0,75	0,75	MtCO2eq	
	(2) Arable land to forest:	Slider	Shifting	30,00%	of arable land to forest each year			
	current	2050	2040	2050	total spatial demand			
	Arable land	2,826,23	1,918,36	1,304,85	363,40	363,40	ha ²	
	Forest	0	047,87	533,51	415,46	415,46	ha ²	
	CO2 reduction	0	0,32	0,55	0,71	0,71	MtCO2eq	
(3) Non-organic to organic farming:	Slider	Shifting	0%	of non-sustainable farming to organic each year				
Propy	kg of fertilizer producer:	5,6	kgCO2eq					
1 ton of non-sustainable farming stop:	1158.7	kg of fertilizer						
current	2050	2040	2050	total				
Organic	0%	228,10	1,008,14	1,350,36	1,934,38	2,826,23	ha ²	
Non-sustainable	30%	2,698,13	1,800,09	1,274,85	893,84			
Fertilizer use (kg)	30,075,702,19	21,022,391,53	14,737,034,07	10,215,385,88	n/a			
CO2 emission (MtCO2eq)	0,86842393	0,17826753	0,04227287	0,02793409	0,14	MtCO2eq		
CO2 reduction (MtCO2eq)			0,85	0,84	0,82	0,82		
Total CO2 reduction			0,72	1,17	1,48	1,48		

The Driver Principles, the Metric Summary and the Detailed Action per theme are directly correlated.

The Phasing Curve responds to the Driver Principles, and the Governance "scenario" that is being tested through the Decarbonization tool.

The overall Summary shows the results of how much carbon can be reduced and space can be saved through this combination of actions.

The order of application of the Driver Principles in time determines the phasing curve for the decarbonization process.



A tool to assess co2 reduction

After we have defined the actions for regeneration per system in transition, we know based on forecasting current state-of-the-art research and knowledge on behavior change etc. what is possible per system in transition to reach a regenerative and resilient Luxembourg functional region in 2050. But this is not enough. all the actions per system will need to be aligned and linked so they are not contradicting or hindering each other, especially in the limited space we have in the functional region. That is why we developed two extreme governance scenario's based on our research findings to investigate how all transitions together could be driven in Luxembourg.

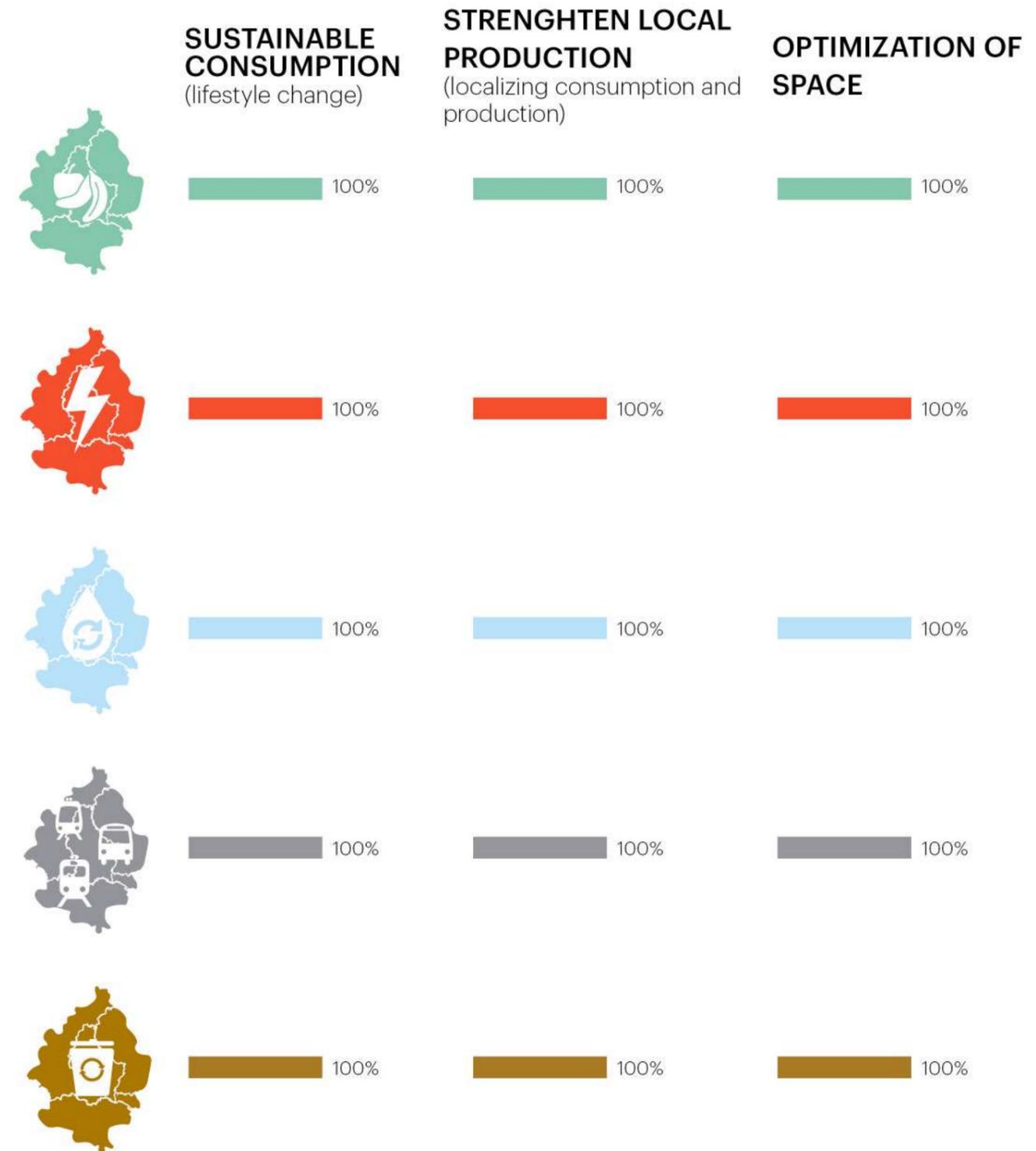
We used backcasting and scenarios to design the governance approach. Backcasting means that you think back from a long-term desired and sustainable future to the now. By imagining the desired future, it becomes easier to 'predict the now' and describe it in scenarios. This method helps you to reflect on the achievability of the desired future and you become aware of drivers and barriers to realize it. It's also a great starting point for looking at existing initiatives and developments, to interpret them in the context of the desired future and the scenarios that lead towards it. (sources: Vergragt, P. J., & Quist, J. (2011). Backcasting for sustainability: Introduction to the special issue.; Roorda, C., Wittmayer, J., Henneman, P, Steenbergen, F. van, Frantzeskaki, N., Loorbach, D., Transition management in the urban context: guidance manual. DRIFT, Erasmus University Rotterdam, Rotterdam, 2014; Wittmayer, J. M., & Loorbach, D. (2016). Governing transitions in cities: fostering alternative ideas, practices, and social relations through transition management. In Governance of urban sustainability transitions (pp. 13-32). Springer, Tokyo.)

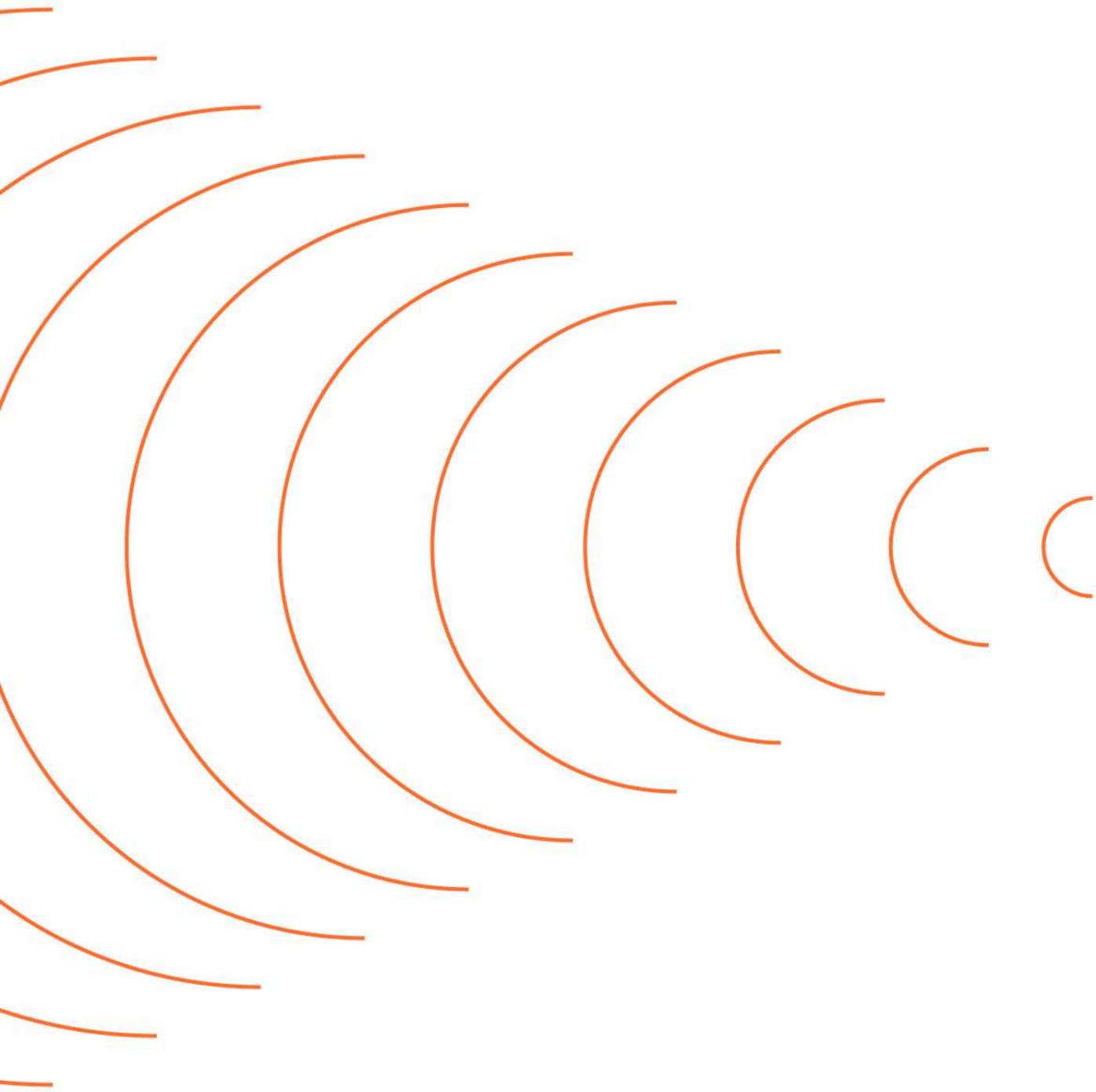
The scenarios were created in an iterative process, that we will now present in a simplified version. in reality this process was repeated several times. The input for this process we gained from interviews with local actors from Luxembourg and by our analysis we made for the previous phase. For the interviews we designed a miro template to map the transition dynamics in Luxembourg together with the interviewee. We used the x-curve as a tool to guide the conversation, starting with asking the interviewee to imagine the desired future for Luxemburg and then what needs to phased out, built up and rebuilt to reach that future. Afterwards, we organized all the input according to the different themes (food, energy, mobility, water, waste). From this analysis we supplemented our spatial analysis and governance analyses from phase one, resulting in two contrasting scenarios, scenario 01: name and scenario 2: name.

The two scenarios were captured in narratives, written from the perspective of a Luxembourg citizen in 2050. We then translated the scenario's into SLIDER positions in the TOOL that calculated impact on CO2 reduction and spatial consumption. Spatial analysis and XXX resulted in maps and images of both scenario's contextualized in the Luxembourg landscape.

We reflected with the consortium on the two scenarios to determine the impact of these very different governance approaches. We also further refined them with input from our experts. To bring the scenarios one step further, we formulated 9 principles that would become the drivers of society in Luxembourg. Based on these drivers and on our reflections on the two scenarios, we co-created the third scenario, name with the consortium and we wrote the narrative, created the spatial maps, ect etc.

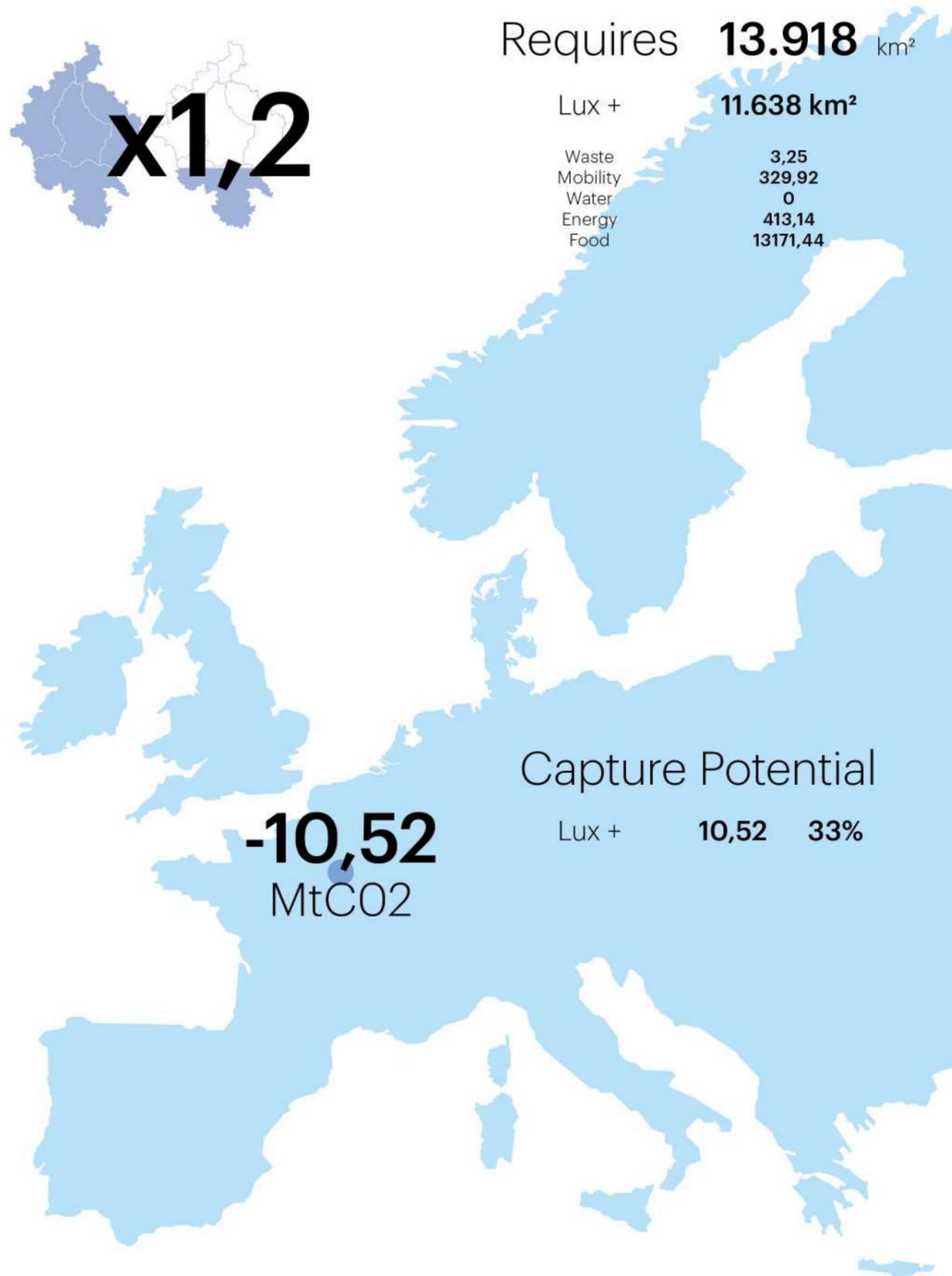
Dependent on sliders position



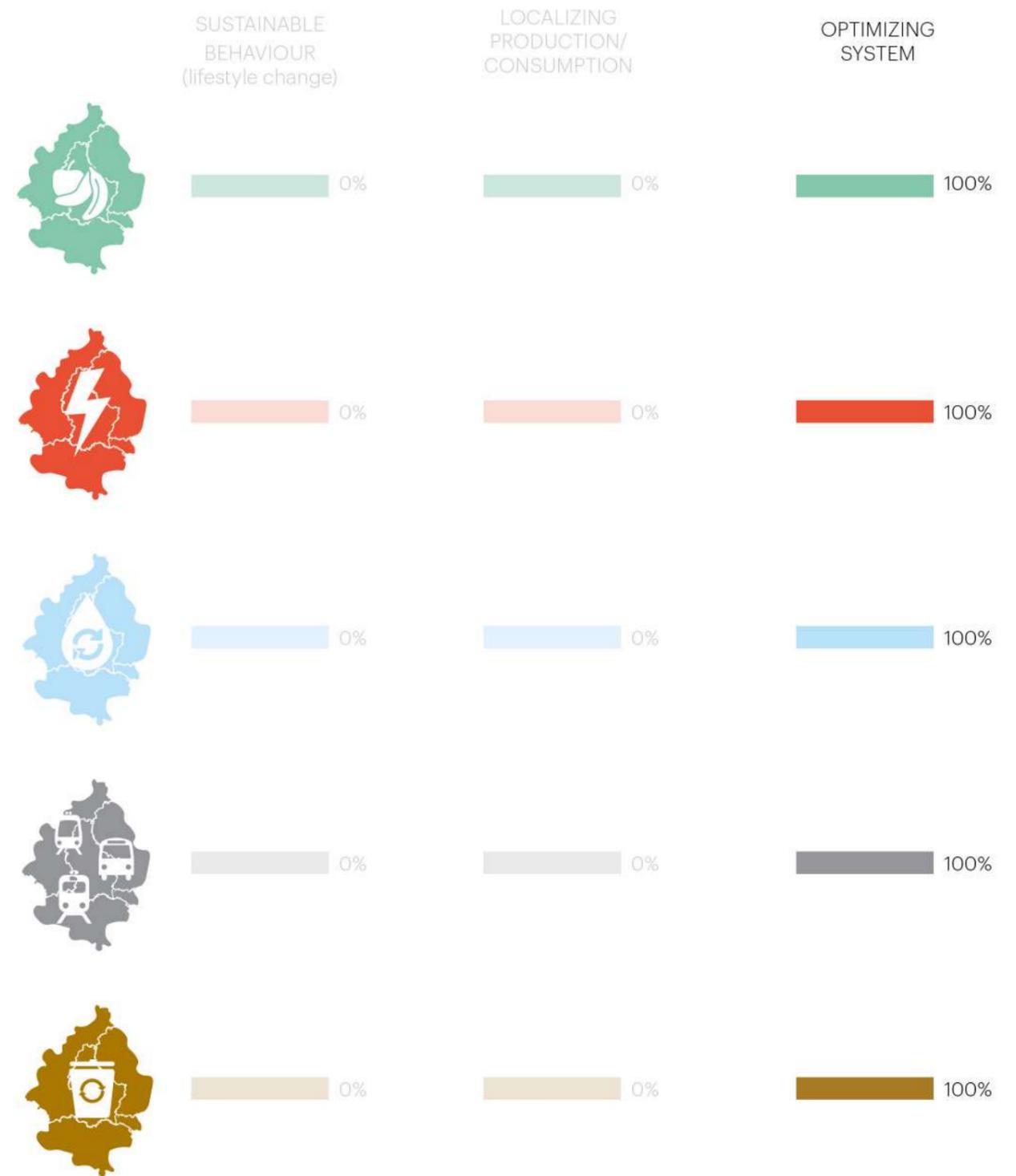


Testing the tool

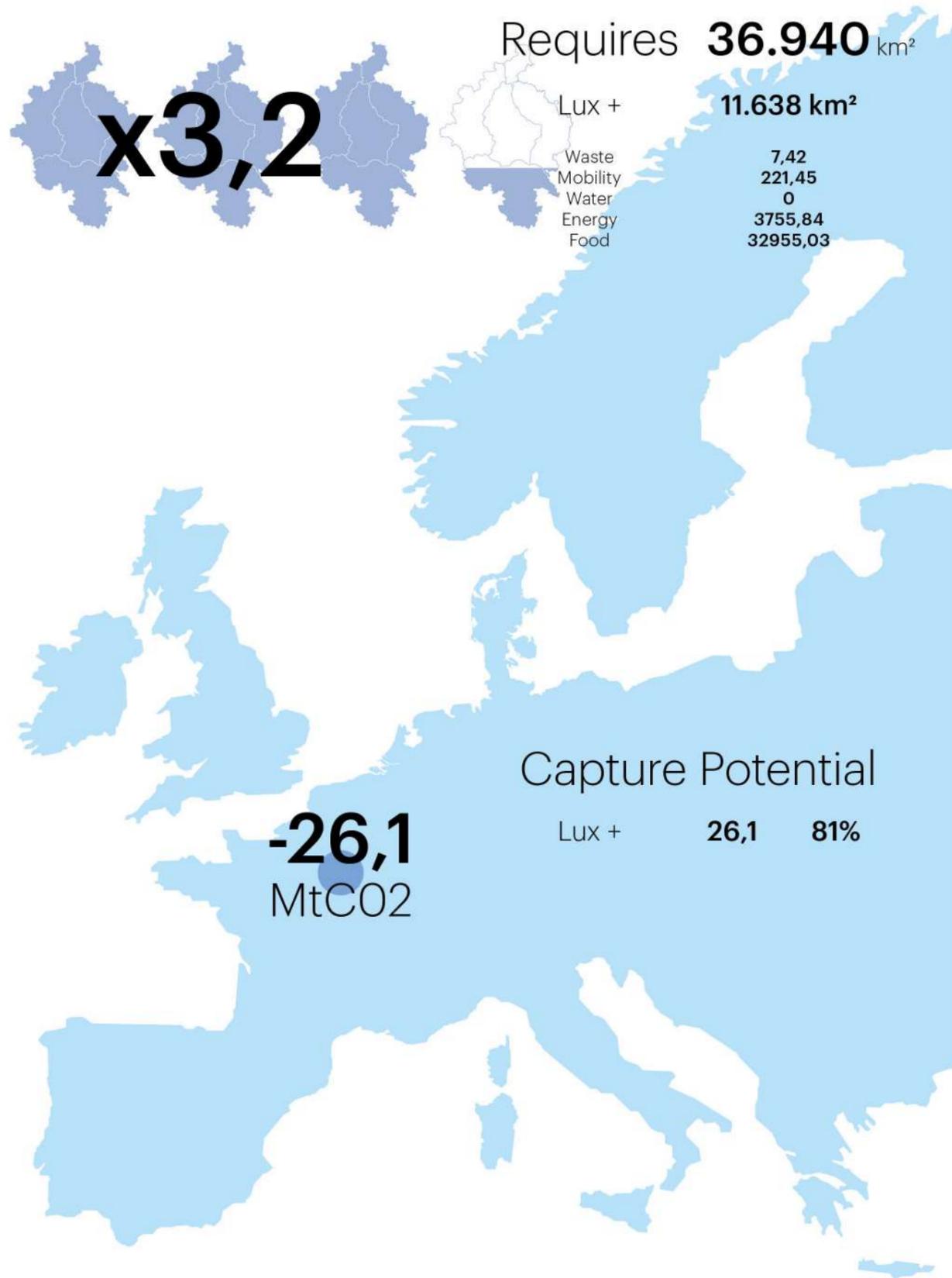
What if...



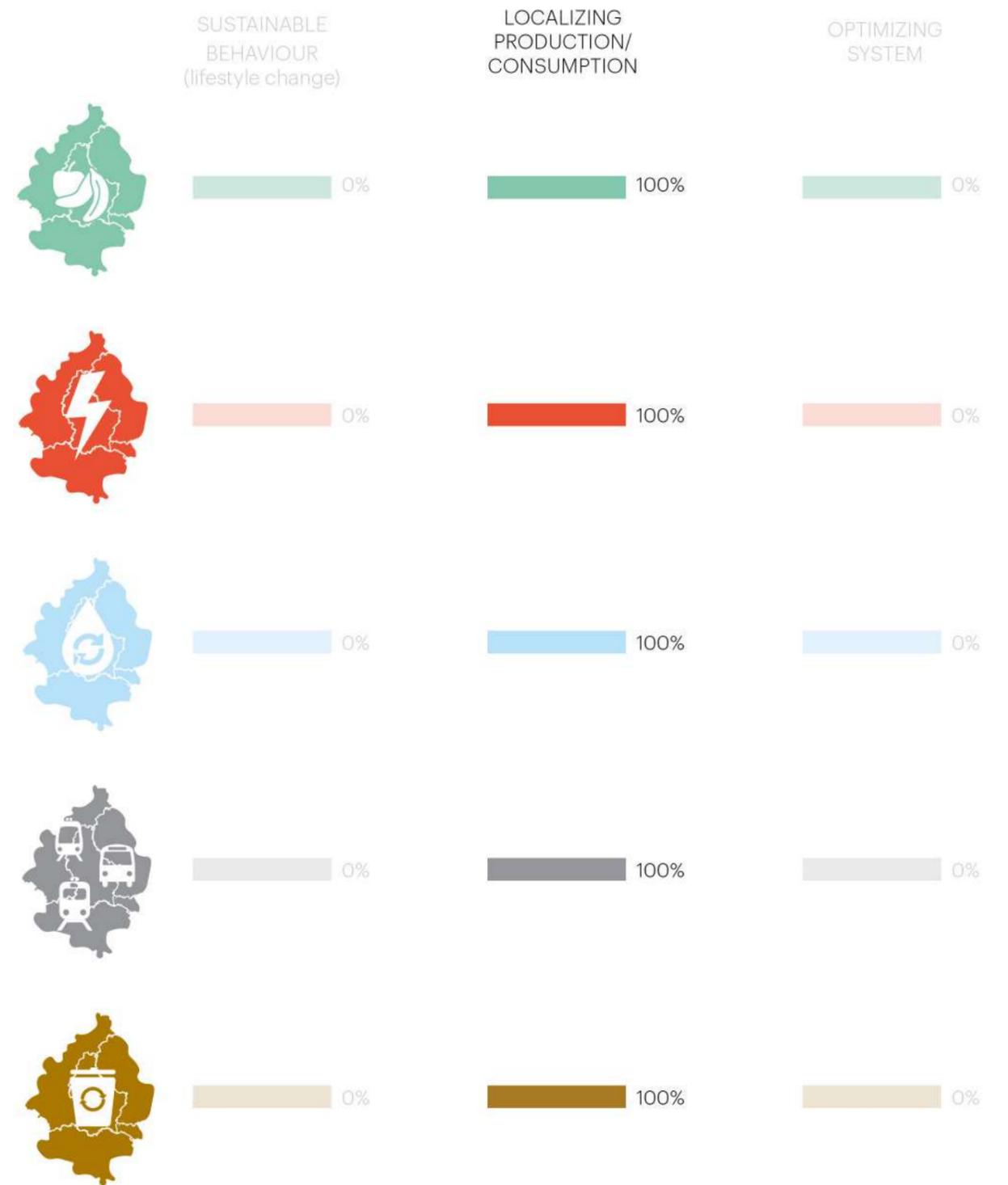
...we only optimize systems



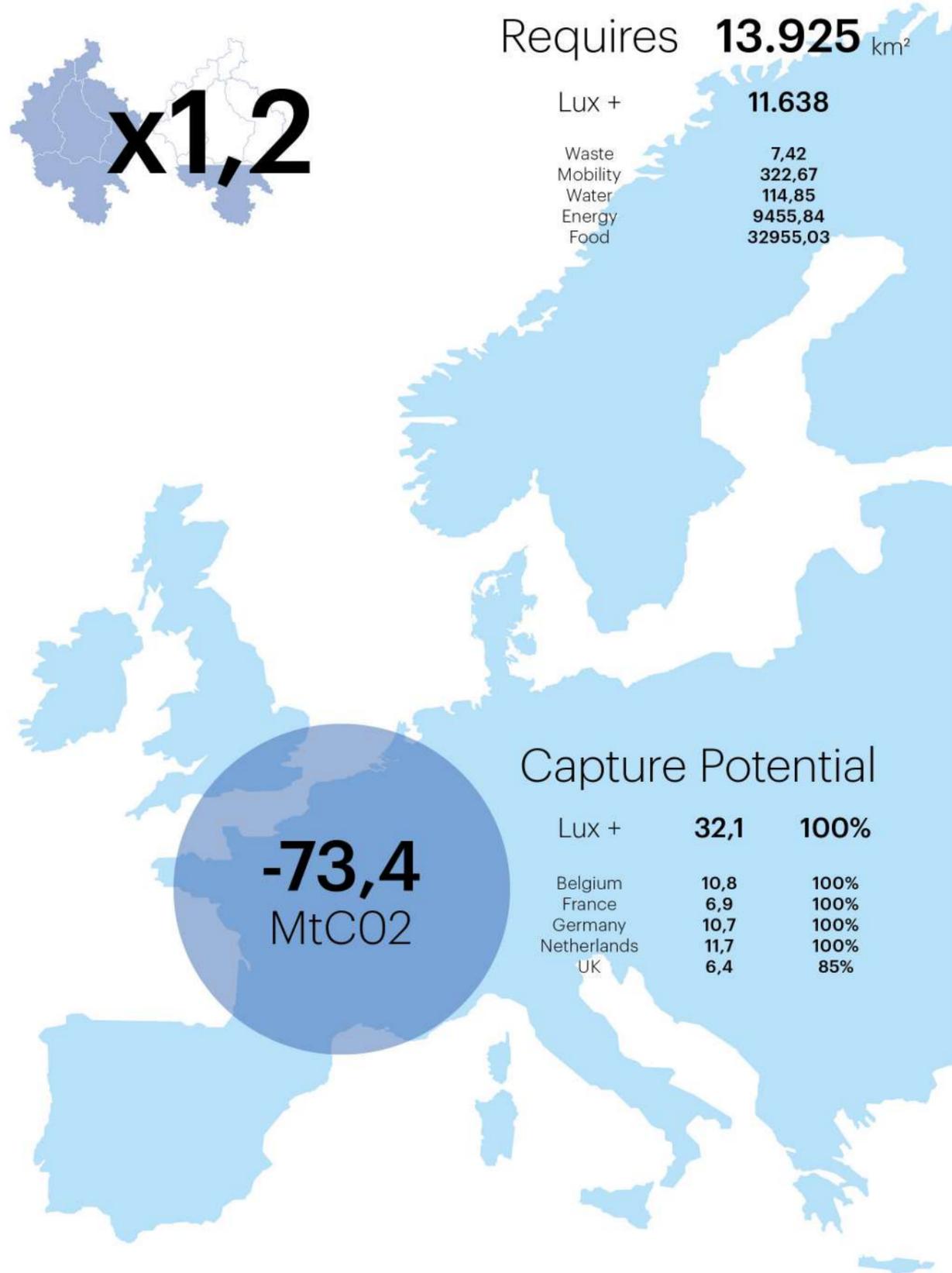
What if...



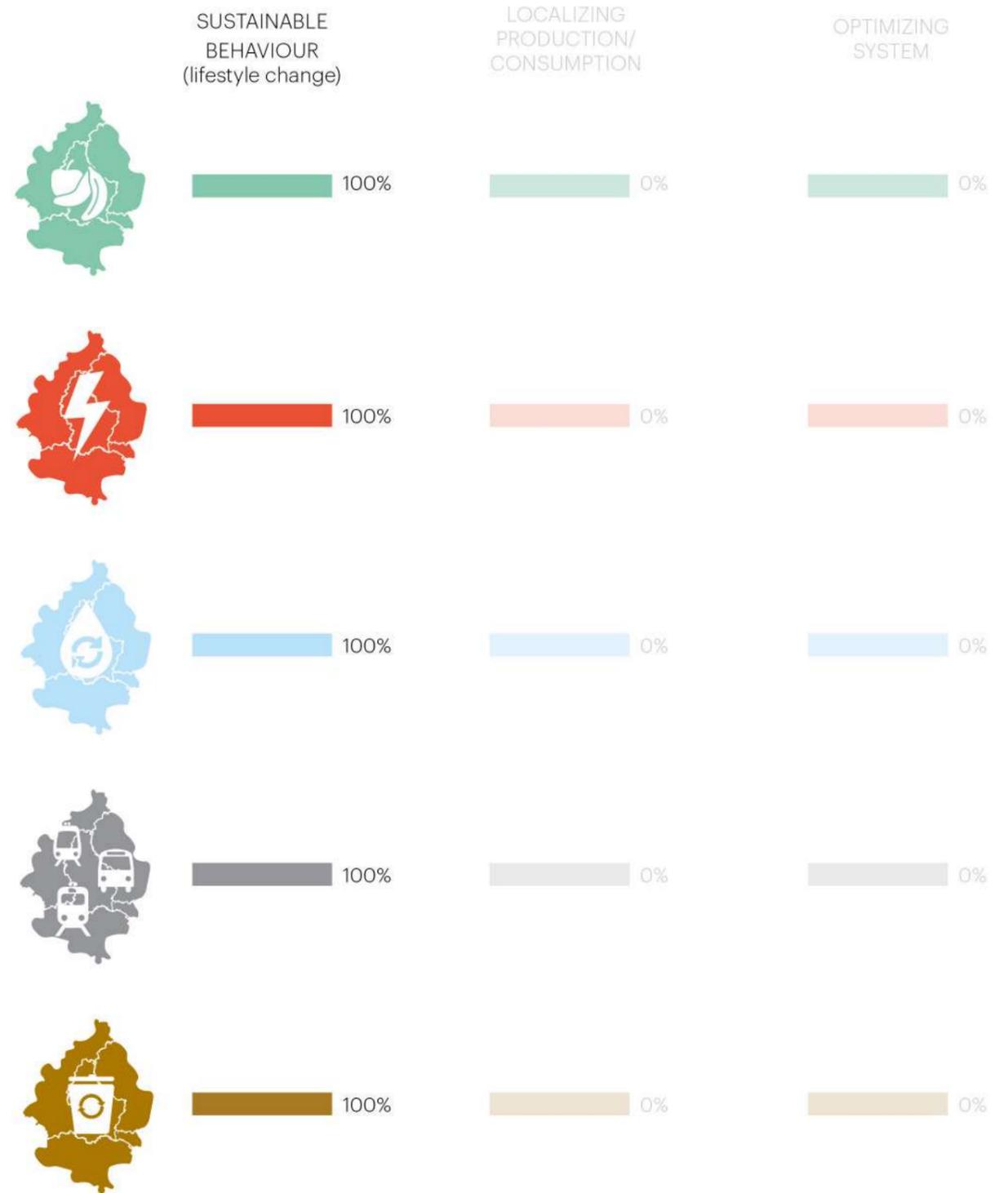
...we only localize



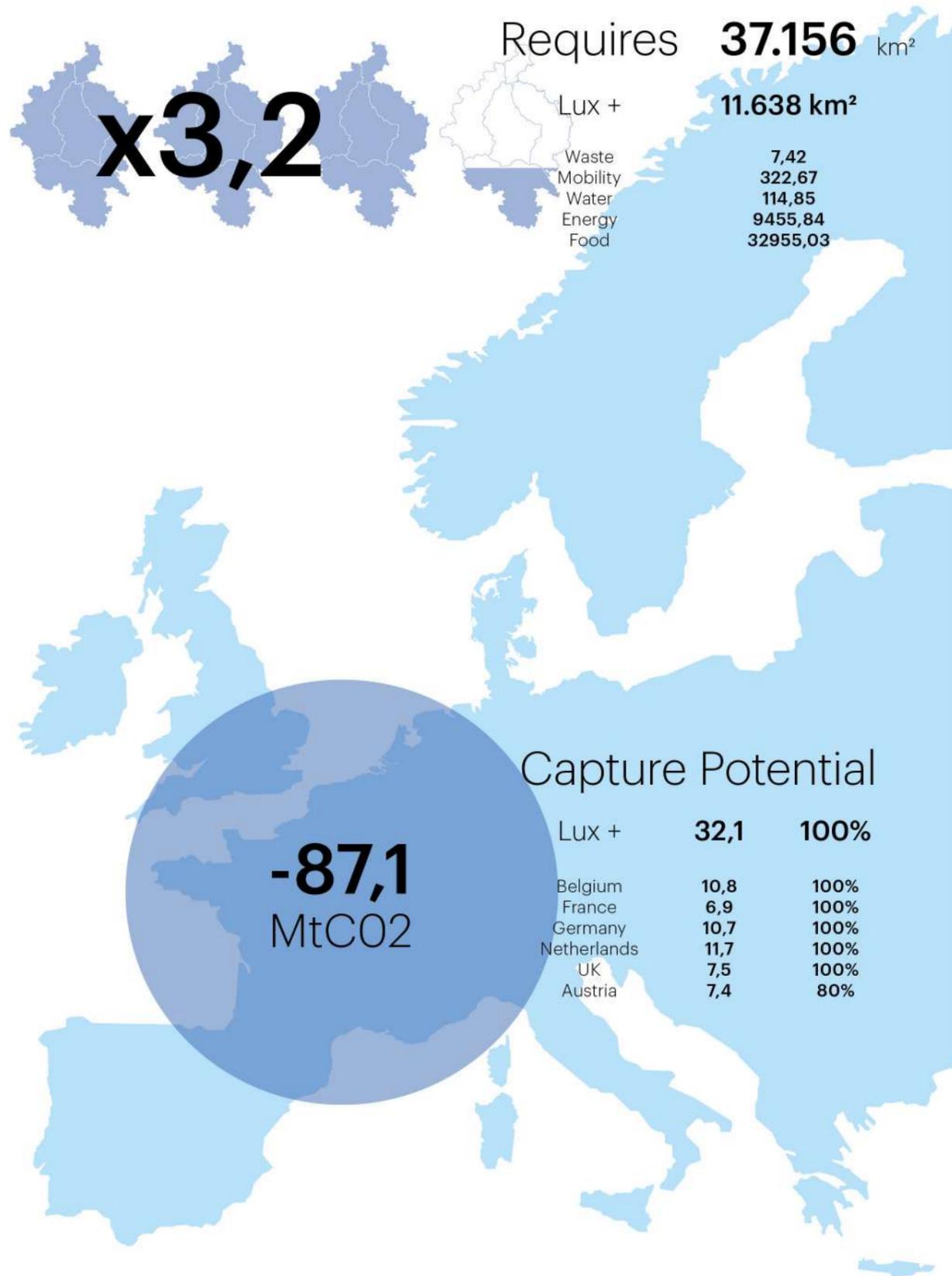
What if...



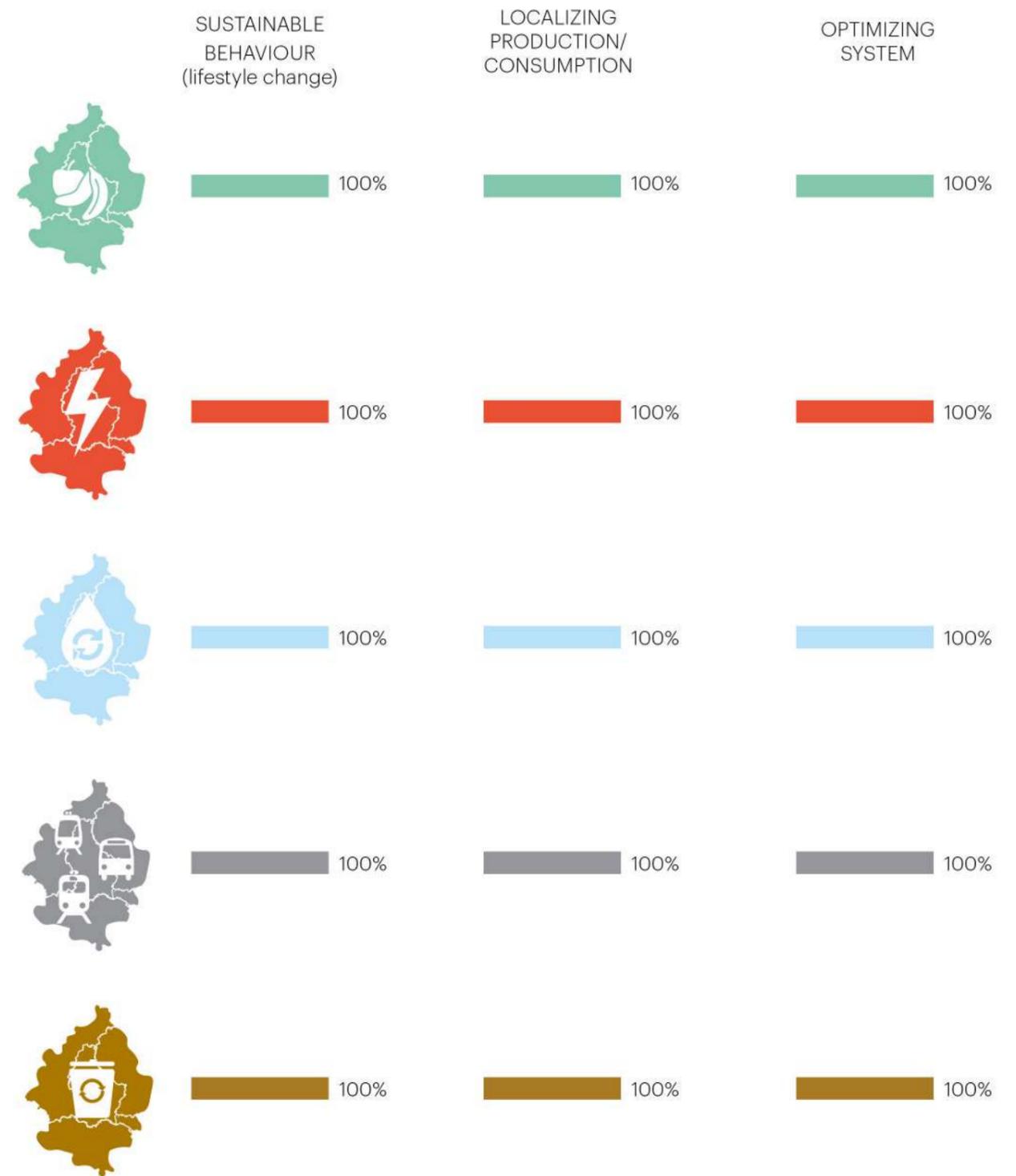
...we only change lifestyle



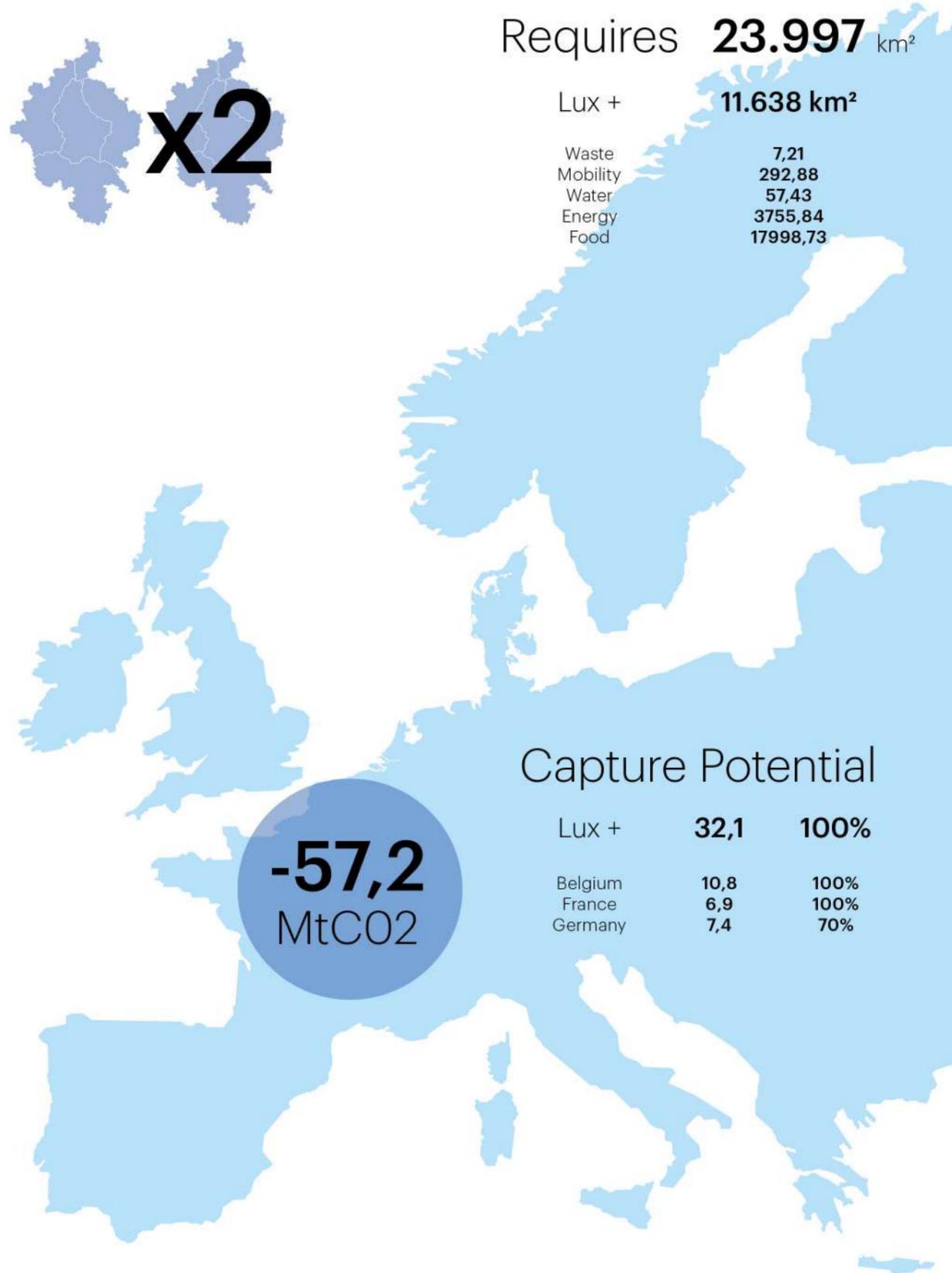
What if...



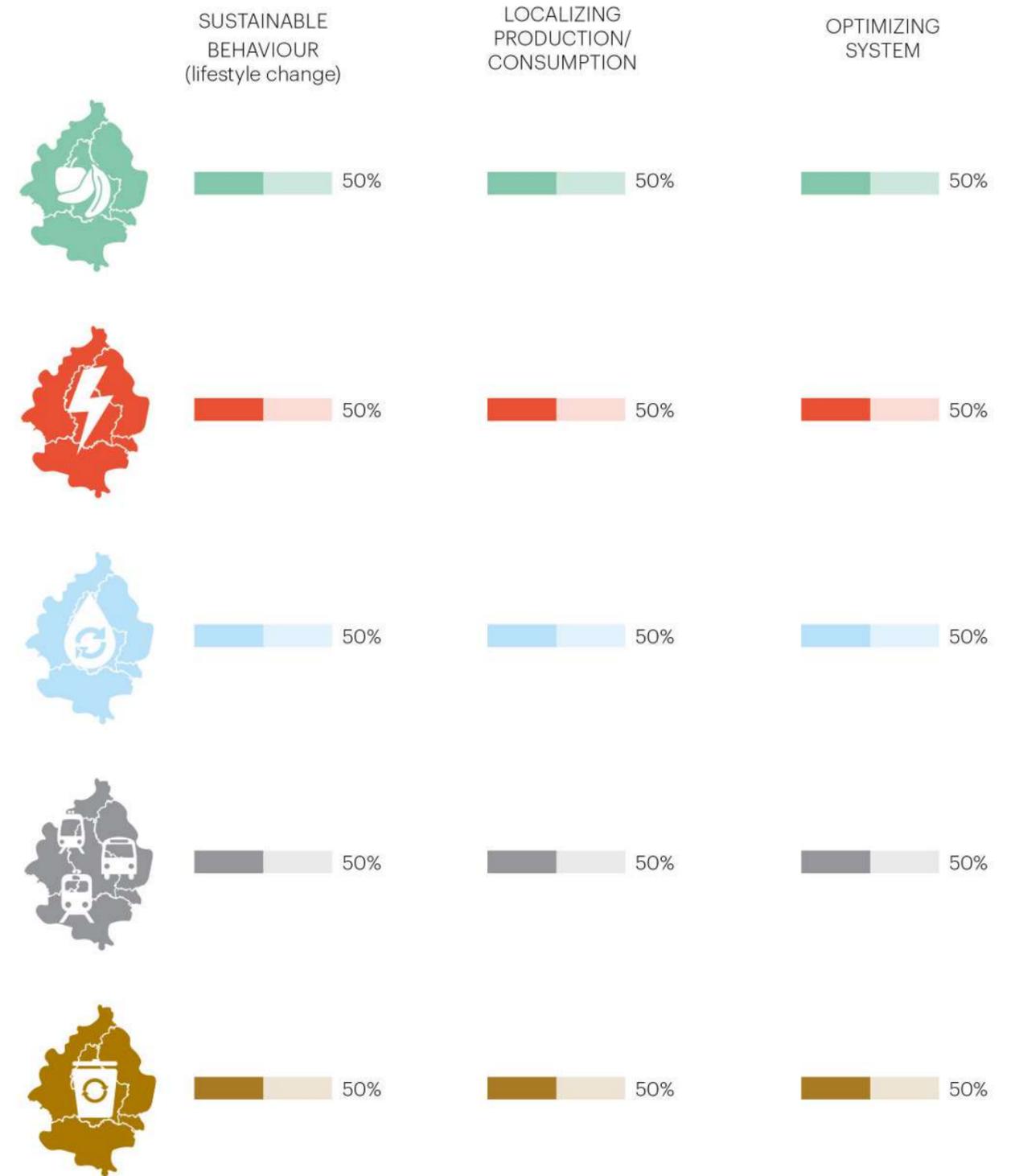
...all actions at 100%



What if...



...all actions at 50%



What if...

What if...

What if...

What if...

What if...

What if...

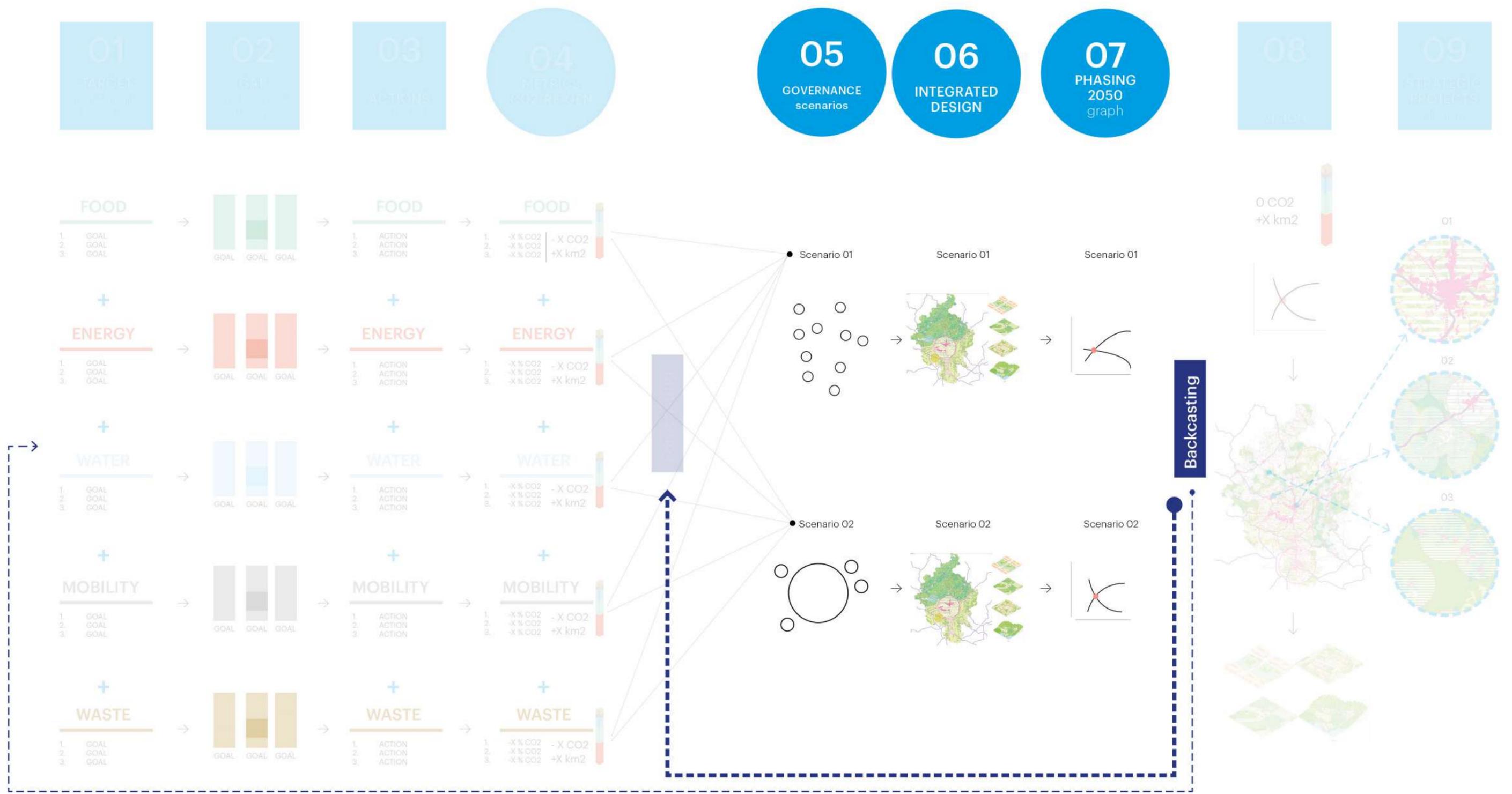
...infinite options

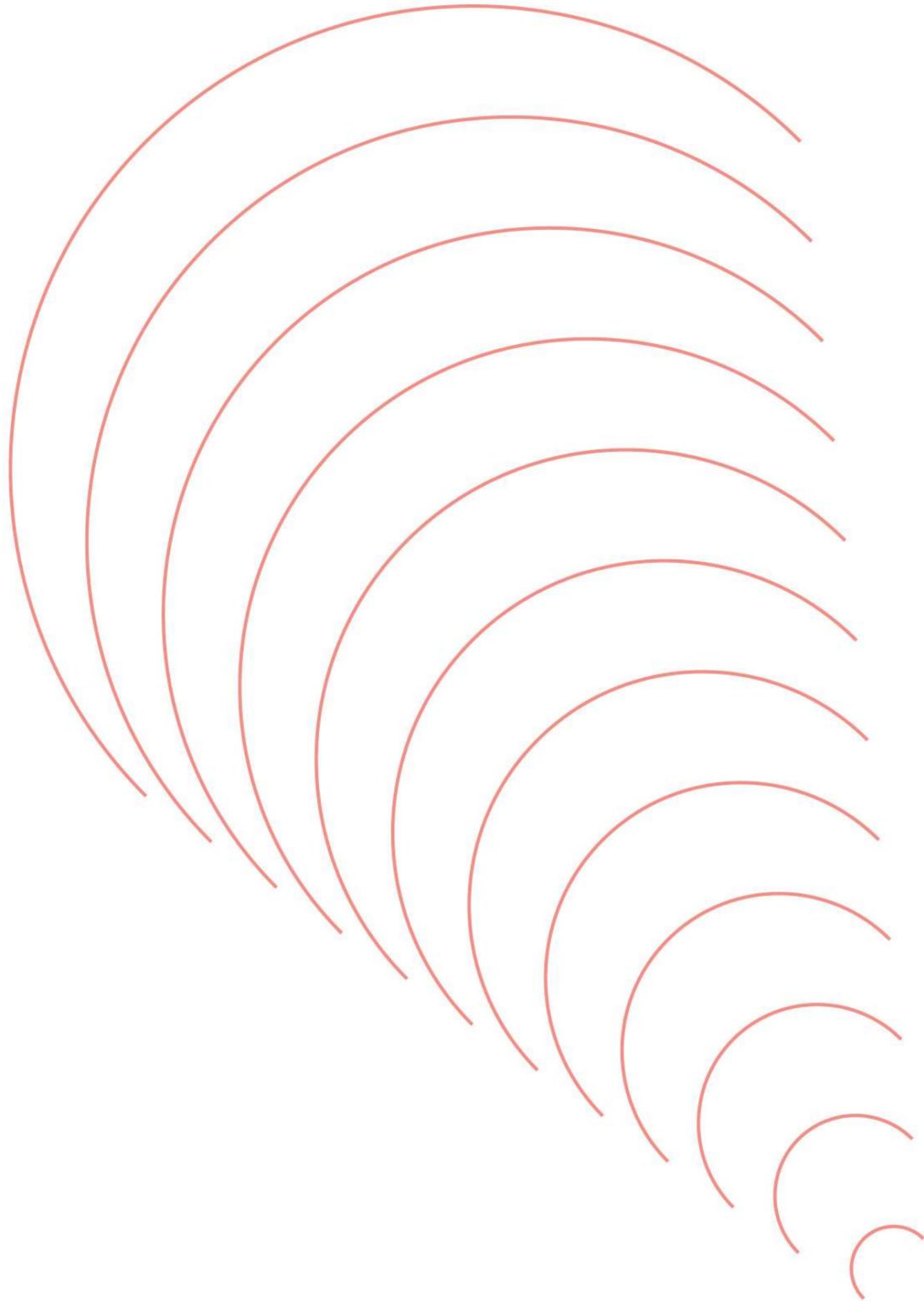
How do we
chose sliders
position?

Governance scenarios

Governance as decision maker
Scenario 01: Going local
Scenario 02: Coordinating spaces
Lessons learned

5





Governance as
decision maker

Defining a scenario

The decarbonization tool reveals the fact that there is an unlimited possibility for scenarios that can facilitate decarbonization. However, not only does the analysis reveal particularities, but an interview process with key stakeholders, indicates that the governance of the territory will determine the definition of a scenario.

Although the expertise assembled should define the scenario, this study explores two theoretically extreme positions based on two governance approaches.

In order to be able to compare, and contrast, and reflect on the results of these scenarios, the study adheres to a consistent approach and methodology to define, explore, and evaluate the scenarios.

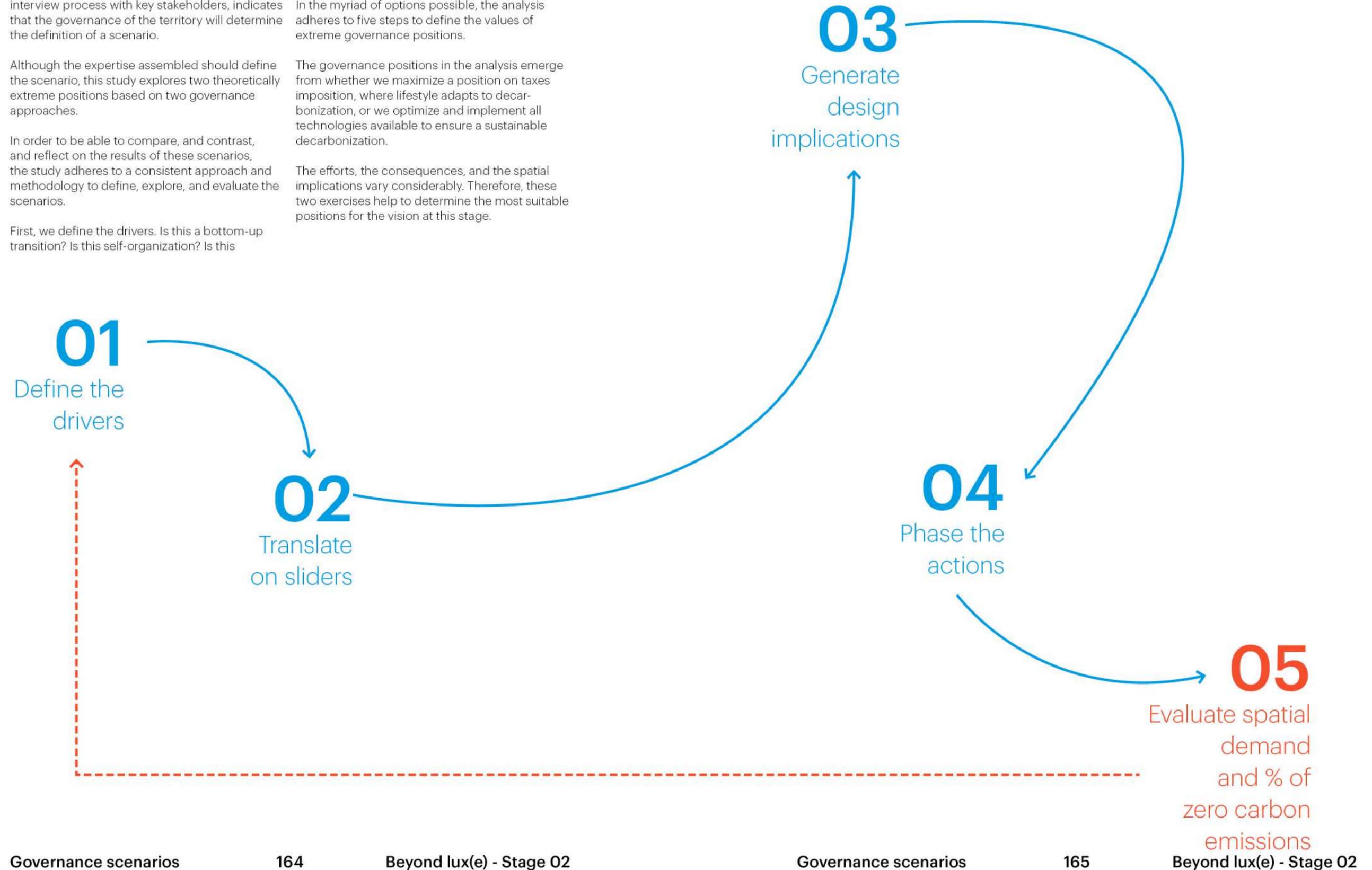
First, we define the drivers. Is this a bottom-up transition? Is this self-organization? Is this

centralized investment? Does this involve imposing policies on lifestyles or changing spatial infrastructure?

In the myriad of options possible, the analysis adheres to five steps to define the values of extreme governance positions.

The governance positions in the analysis emerge from whether we maximize a position on taxes imposition, where lifestyle adapts to decarbonization, or we optimize and implement all technologies available to ensure a sustainable decarbonization.

The efforts, the consequences, and the spatial implications vary considerably. Therefore, these two exercises help to determine the most suitable positions for the vision at this stage.



Back to the future: Rachel

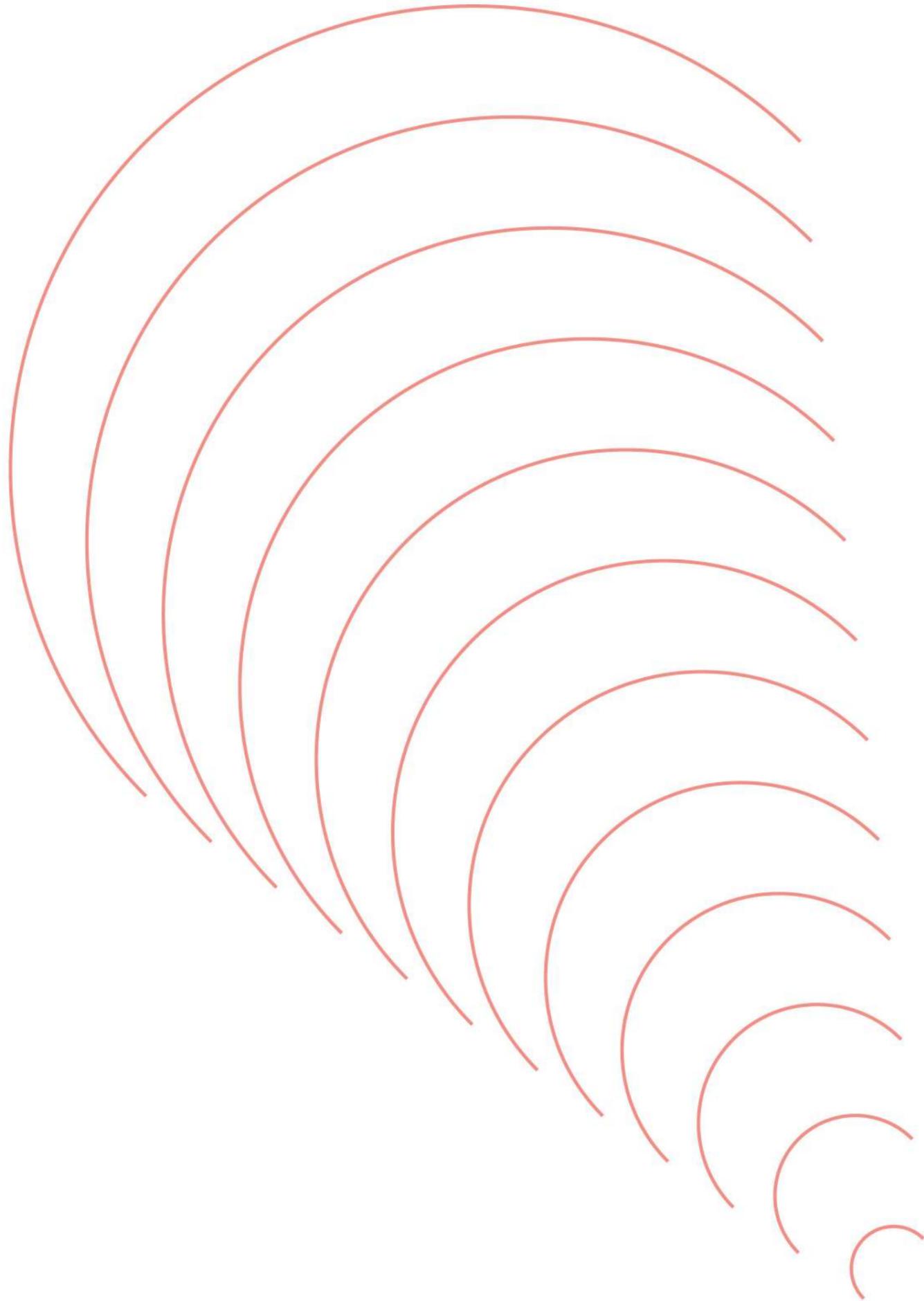
Looking back on the effects of each scenario from 2050, is Luxembourg City regional planner, Rachel Hoffmann.

As a key note for ISOCARP 2050 in Vancouver, Canada, Ms. Hoffmann addresses a theatre filled with planners from around the world, to share how Luxembourg's functional area serves as a leading example of massive systems change.

In the pages that follow, we explore, through Hoffmann's eyes, how each scenario might have developed, paving the path to the resilient future that Luxembourg's functional area enjoys in 2050.



Our Persona:
Luxembourg City regional planner,
Rachel Hoffmann.



Scenario 01:
Going local

What is scenario 01 by 2050 in lux+?

It is strange to look back at the past 30 years. Since the COVID crisis and the climate protests, much has changed in the functional region. We were working on alternative strategies to change our carbon intensive lifestyles for years back then, but never succeeded implementing the necessary changes. The consultation process Luxembourg in Transition inspired the Ministry of Energy and Spatial Planning to be courageous. A collaboration of several ministries with scientists, businesses and citizens led to a set of drastic measures to change the lifestyle of Luxembourg society. In 30 years time Luxembourg was going to change from a country with the highest carbon footprint of Europe to the one with the smallest footprint in 30 years.

This change was kick-started with the introduction of a carbon tax and the reduction of the labour tax. This made all products with high CO2, like a meat based diet, long distance commuting and international flights, very expensive. Repairing your electronics, sharing your car and investing in the local economy on the other hand became very attractive. Consequently, the economy rapidly

transformed into a regional economy with local currencies and high-tech up-cycling facilities. Nothing was wasted, new buildings were made from re-purposing existing one supplemented with locally sourced wood. Clean energy was produced locally and sufficient to supply a coalition of municipalities.

The focus on scale of a coalition of municipalities became more important than the national scale, which resulted in different types of identities for every coalition, but they all worked by empowering local initiatives from citizens, SMEs and NGOs. For example the Beckerich transition was driven by the citizens commissions and in Bonnert locals set up a network of entrepreneurs that developed innovative solutions for local problems.

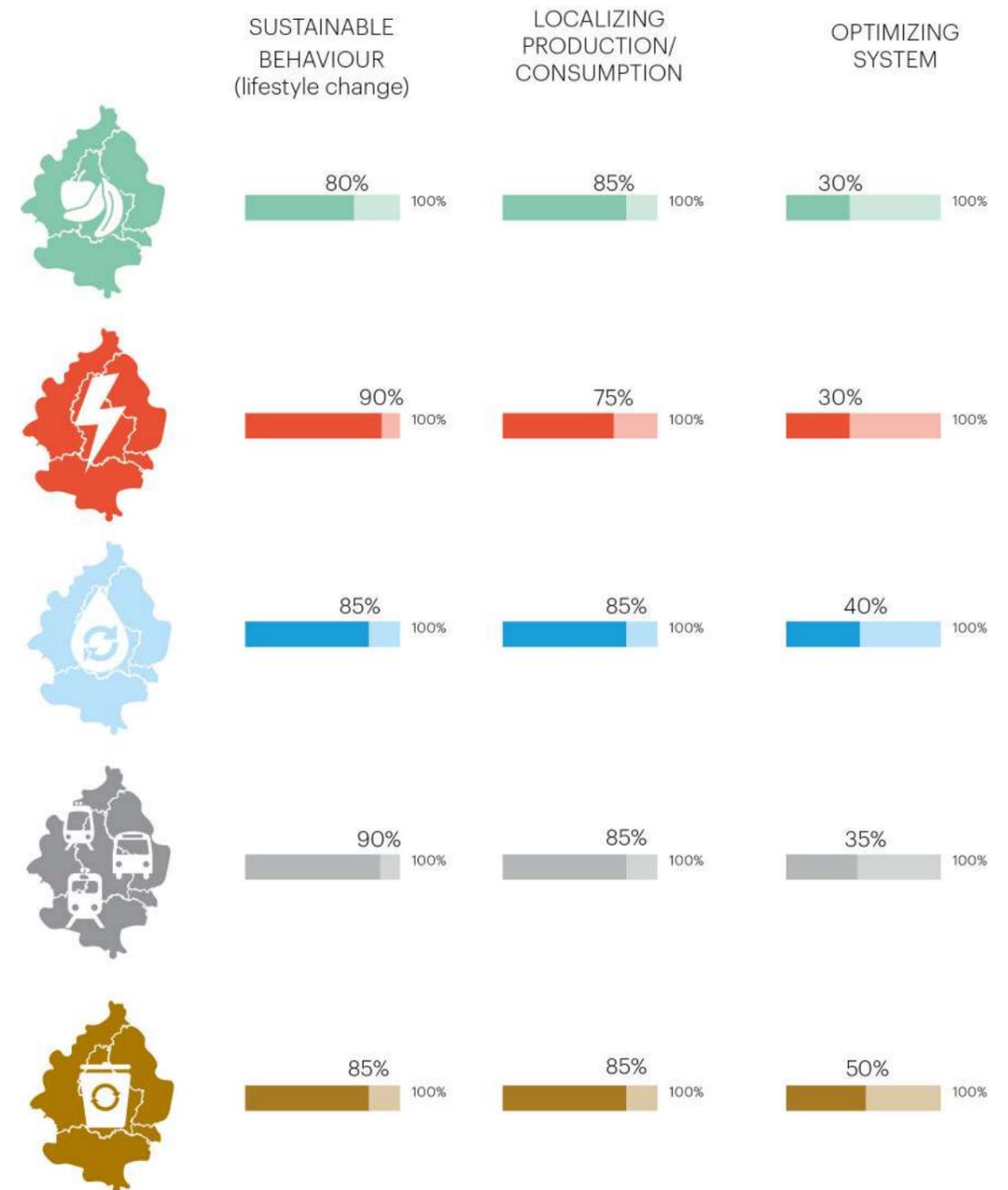


Governance scenarios

170

Beyond lux(e) - Stage 02

The actions: Sustainable Behaviour and Localizing

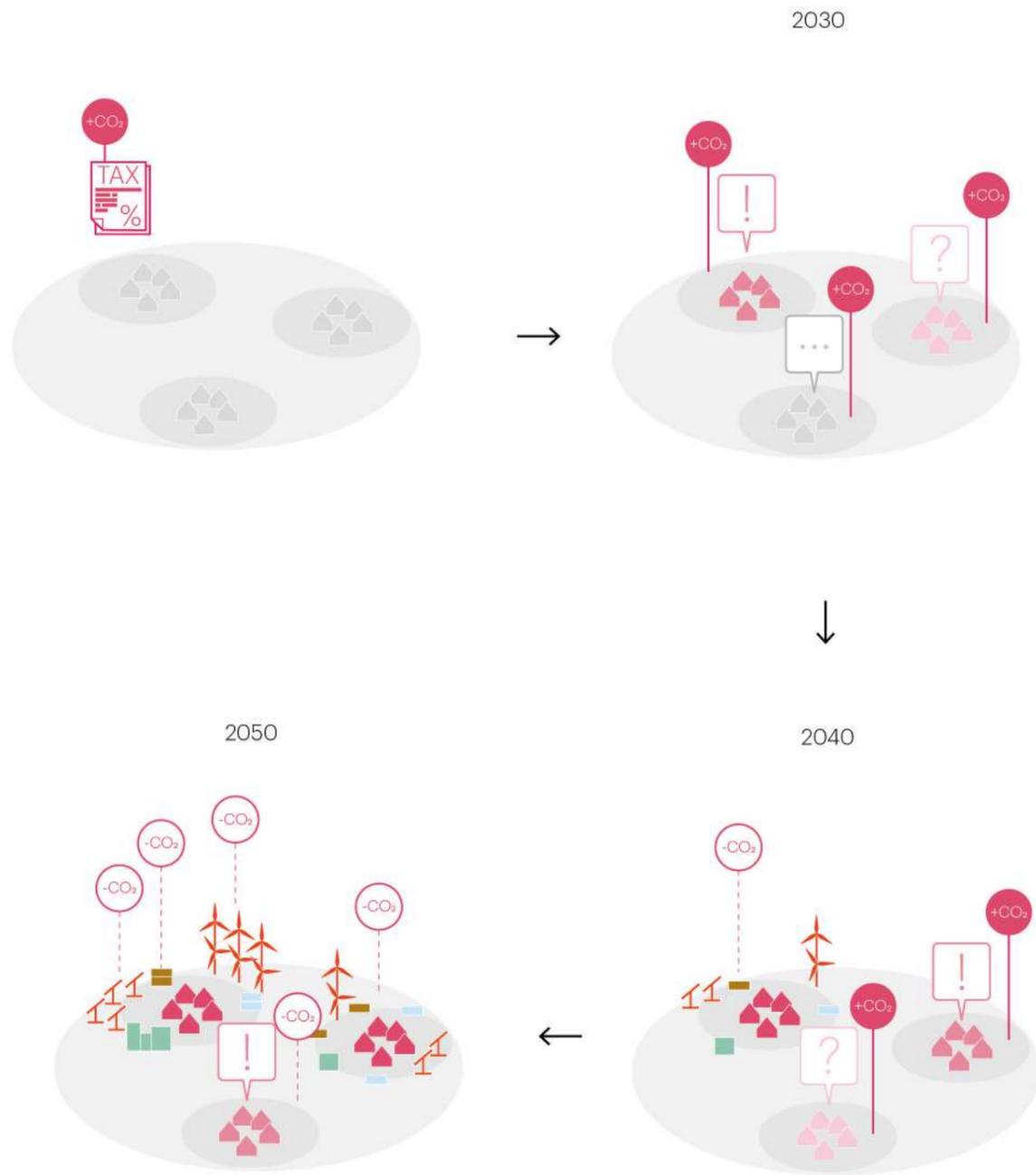


Governance scenarios

171

Beyond lux(e) - Stage 02

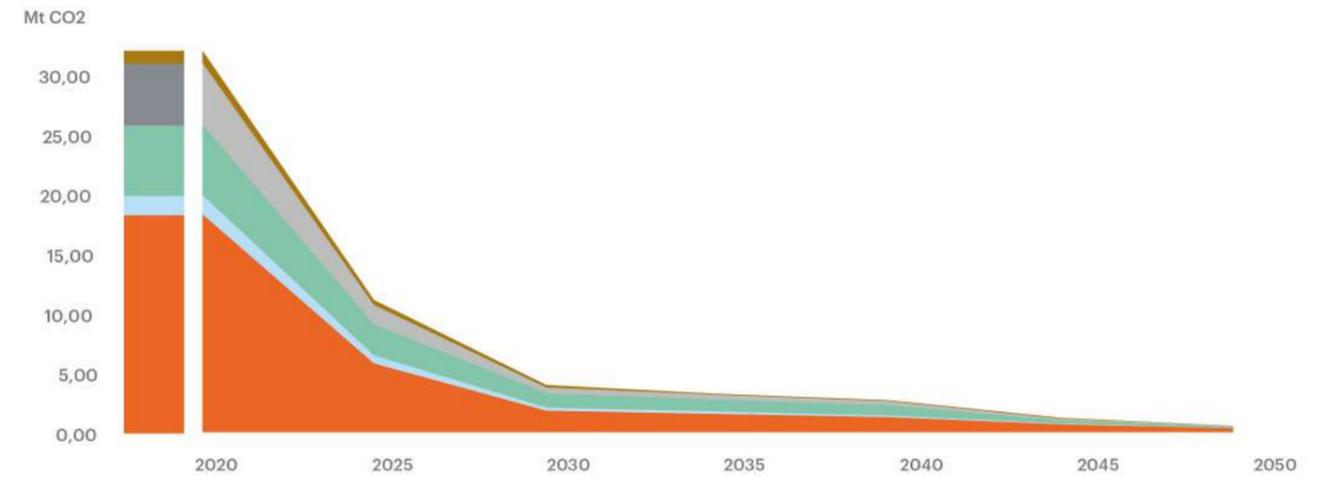
Phasing by 2050



Phasing

	2020	2025	2030	2035	2040	2045	2050
TOTAL	32,0	11,1	3,9	3,2	2,7	1,2	0,5
Energy	18,3	5,8	1,8	1,5	1,3	0,6	0,3
Water	1,6	0,6	0,2	0,2	0,1	0,1	0,0
Food	5,9	2,6	1,2	1,0	0,8	0,3	0,1
Mobility	5,2	1,6	0,5	0,4	0,3	0,1	0,1
Waste	1,0	0,4	0,2	0,1	0,1	0,0	0,0
Year	2020	2025	2030	2035	2040	2045	2050

Reduction of CO2 (Mt) every 5 years



Phasing graph every 5 years

Food

When I look back at 2020, our food system has since changed drastically. Every coalition of municipalities has its own food cooperatives. There, food is produced locally and transported within the coalition's own networks. Coalitions exchange some goods to balance out production and consumption. Food imports have ground to a halt. Pineapples are now so rare that they're an

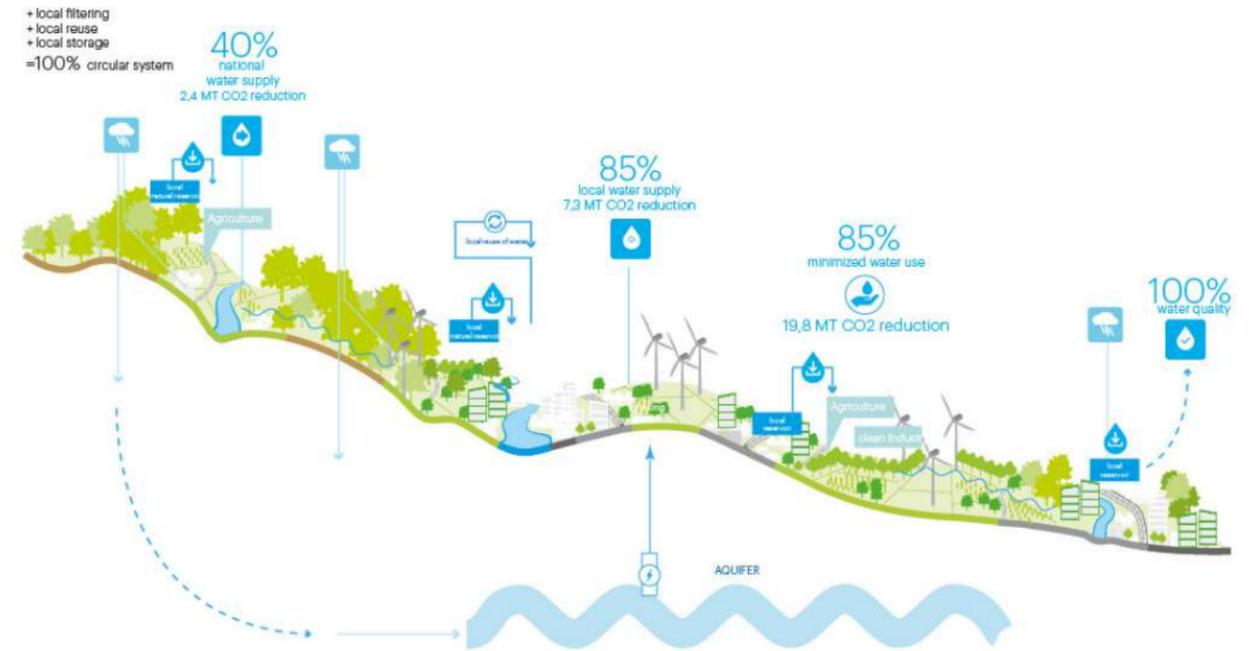
exclusive gift. My husband got one for our 10th anniversary. And of course processed food has been banned completely. The marketing ban for unhealthy and unsustainable food implemented in 2030 worked so well that locally produced and healthy food has become the norm in every household, school canteen, and restaurant.



Water

The building in which I live has integrated water recuperation. This filters our water for continuous reuse.

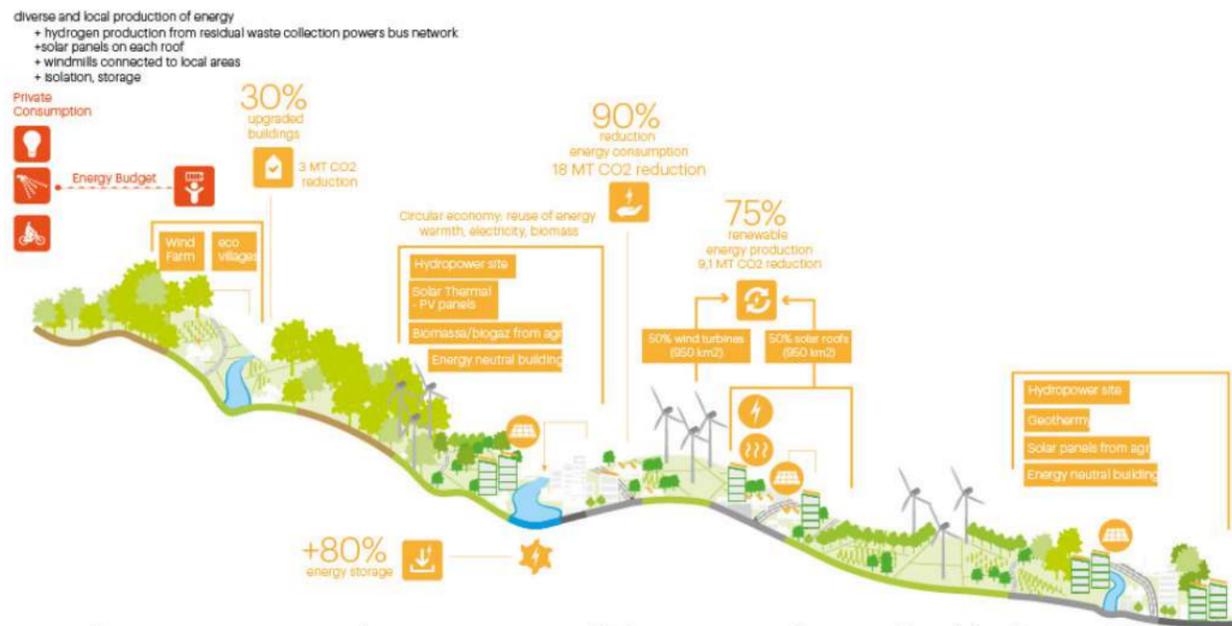
Swimming pools and basements store household water and purification at the tap ensures potable water quality.



Energy

I live in a coalition of municipalities that has become a frontrunner in the implementation of local energy hubs. We collect our residual waste for hydrogen production and this fuels the public bus network. Every building has a solar roof for individual energy consumption. Our neighbouring coalition of municipalities obtains their energy from the mining company that installed large

windmills to produce the energy they needed for their processes. The inhabitants receive some of this wind power as well. Some coalitions of municipalities did not invest in time and unfortunately face high energy prices now - can you believe that they are still importing oil?



Governance scenarios

174

Beyond lux(e) - Stage O2

Mobility

Cars once dominated my city. Thankfully, we now produce hydrogen locally and with the hydrogen, we are able to fuel an excellent public bus network. Besides busses, there is plenty of room for walking and cycling: the old car lanes now accommodate different modes of transport. Some coalitions of municipalities have opted for

another approach. For example where my sister lives, people drive electric cars and these are often shared. This helps to limit carbon emissions, but my sister still complains about traffic jams!



Governance scenarios

175

Beyond lux(e) - Stage O2

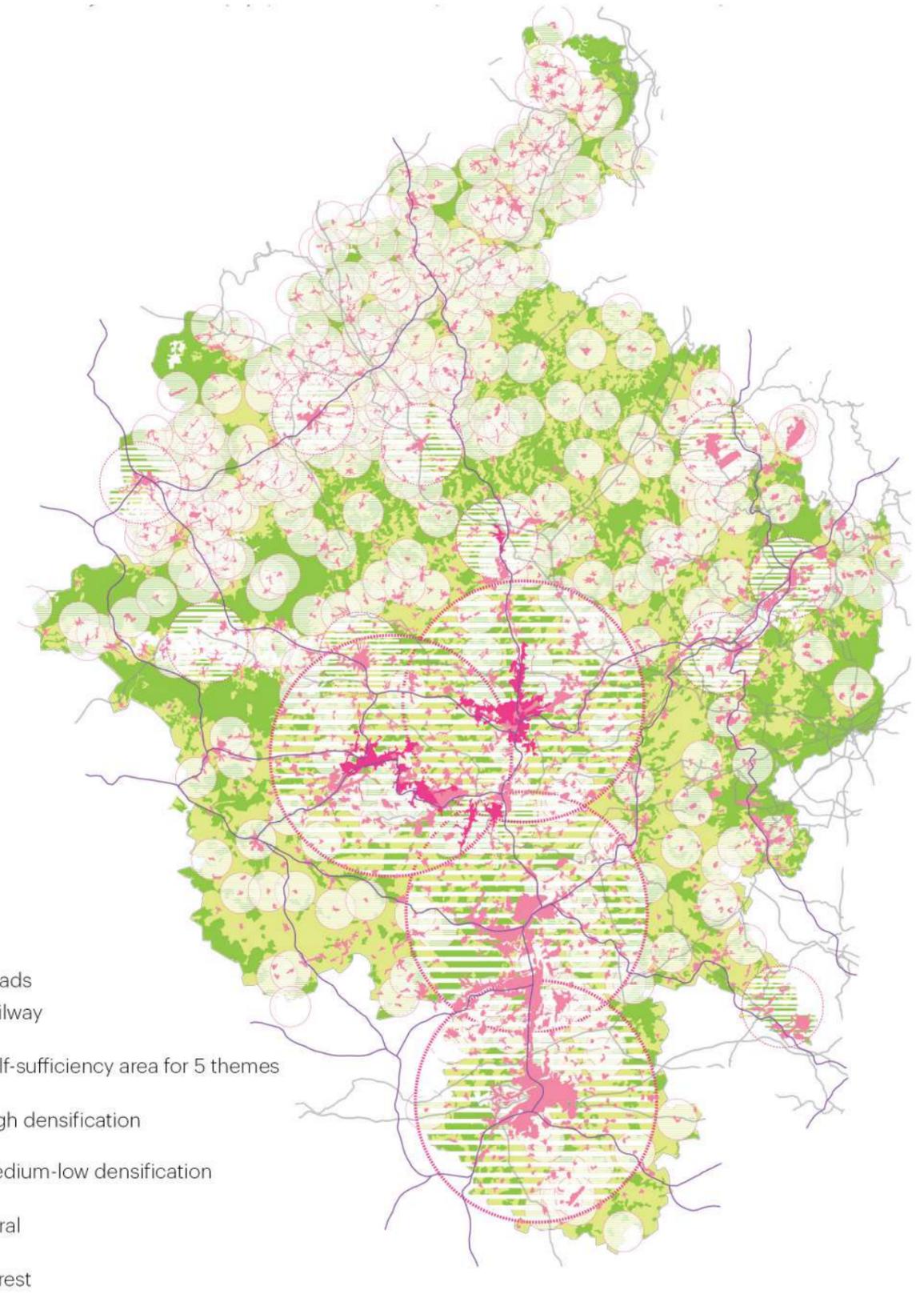
Waste

My husband works at a fab lab. When he established the fab lab 30 years ago, he did not anticipate how popular it would become. Materials are very expensive, so people come by the lab for all kinds of projects that incorporate reused materials. He's closely collaborating with the local wood cluster: they sell him leftover wood from building projects. He's working with a pool

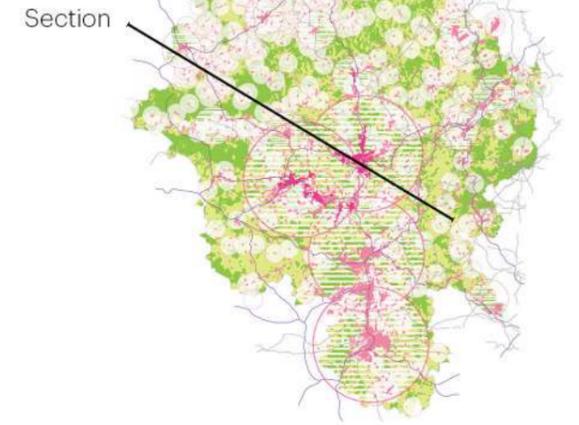
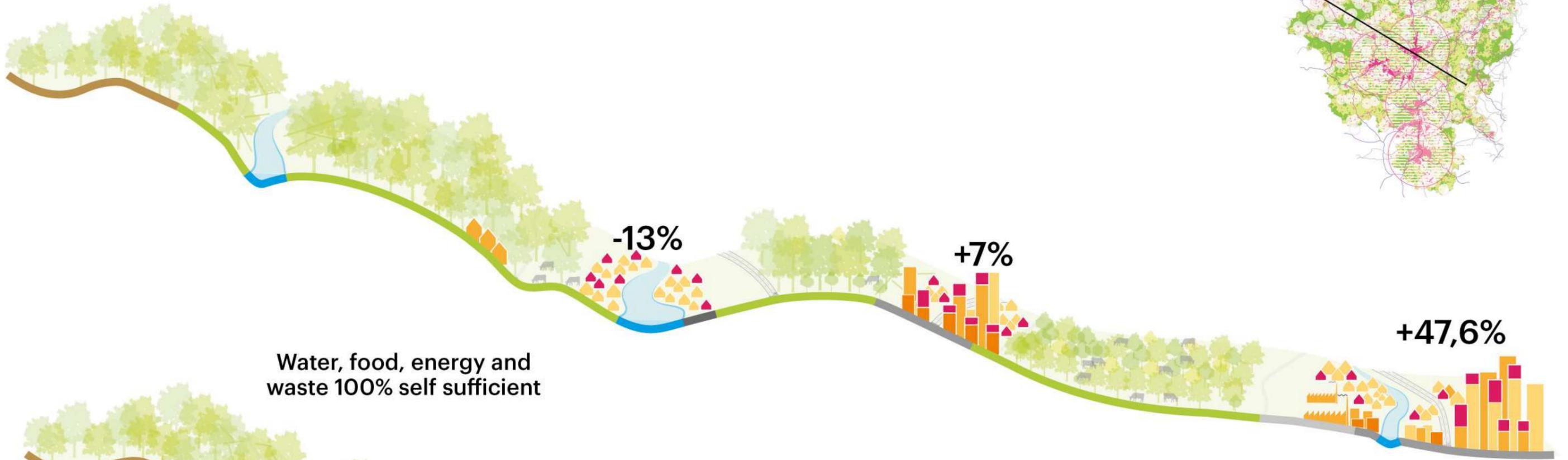
of local carpenters, manufacturers, and construction workers that mobilize the many projects that begin at the local fab labs and innovation labs. These professions are all highly valued and respected nowadays. What a difference from 30 years ago, when having an office with a big computer screen and a great video call background was all the rage



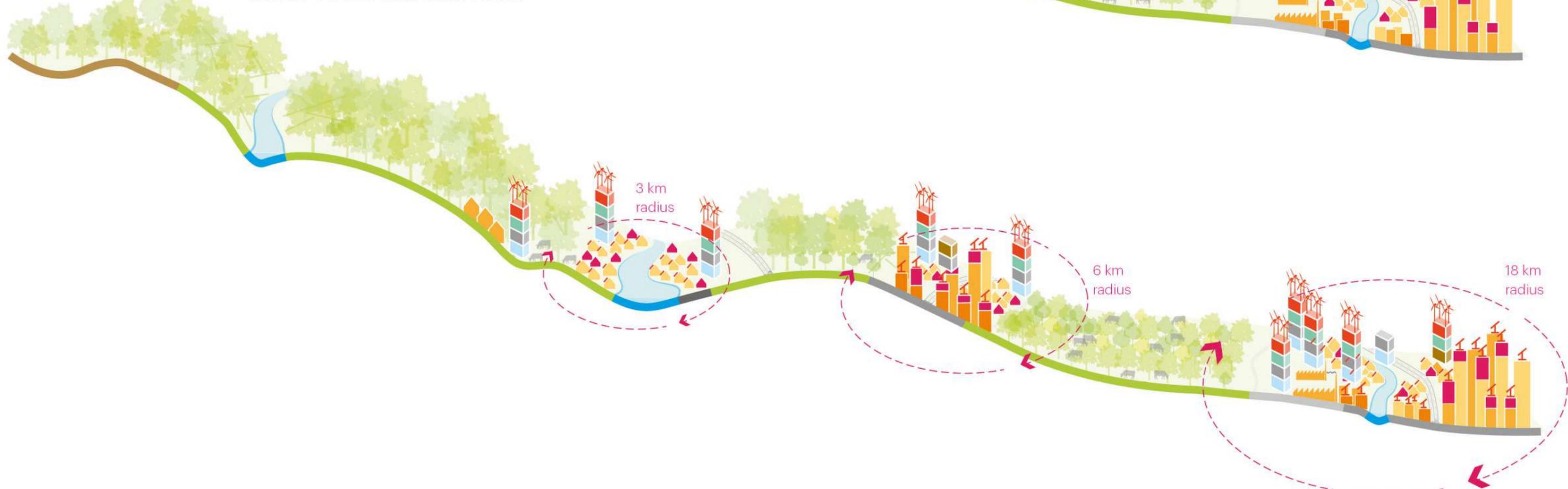
Vision by 2050

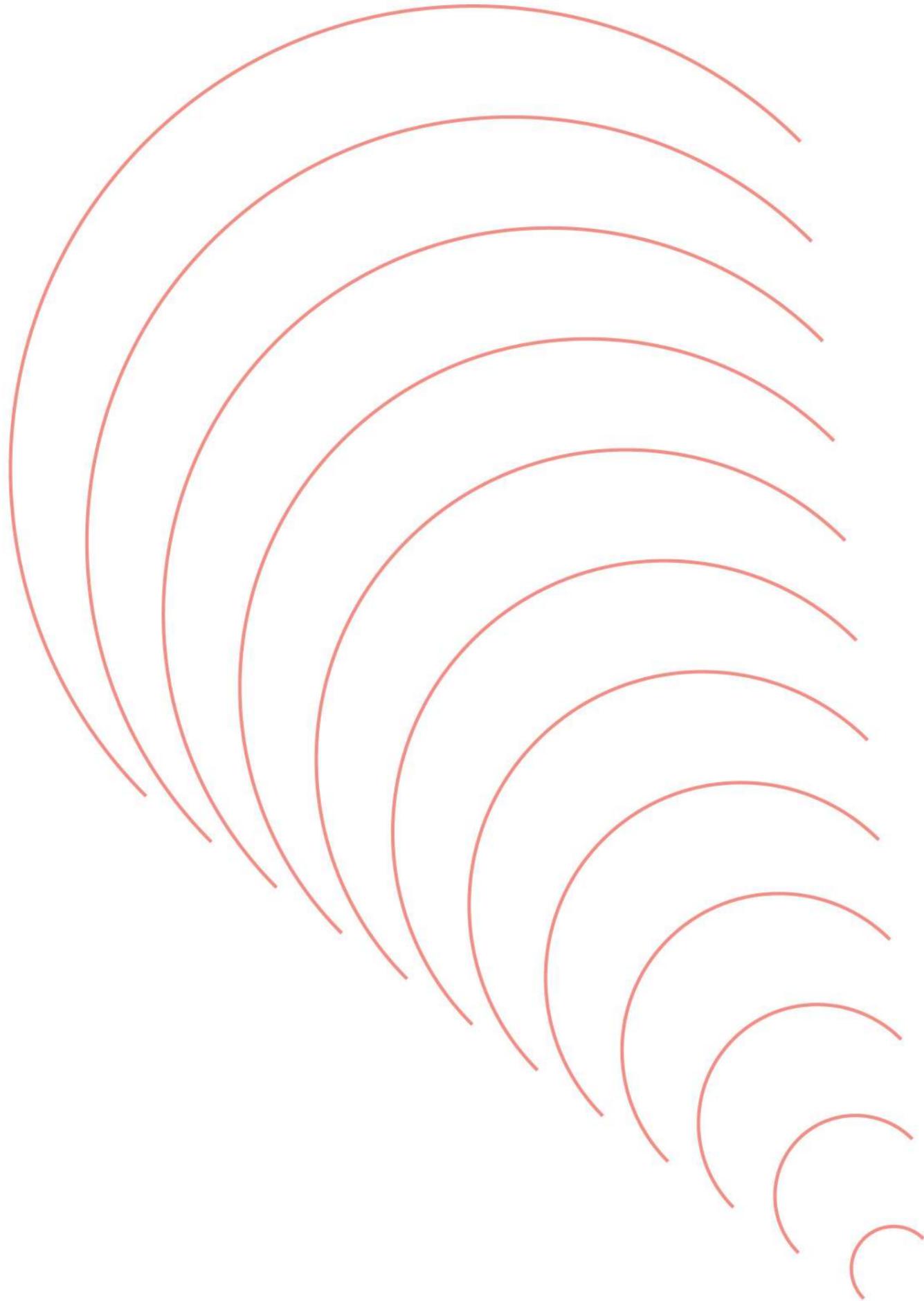


Existing growth pattern



Water, food, energy and waste 100% self sufficient





Scenario 02: Coordinating spaces

What is like lux+ by 2050?

30 years ago, when I was marching with the crowds demanding that our leaders take serious action to address the climate crisis, I could never have anticipated what we've achieved as a society today. Young people hitting the streets in protest, responding to the unprecedented COVID pandemic, and then, an international consultation to create a zero carbon future in Luxembourg: these were all elements that contributed to the mind shift among decision makers. They realised that an ecological transition was the only way forward. From then on, ecosystem services would define spatial planning.

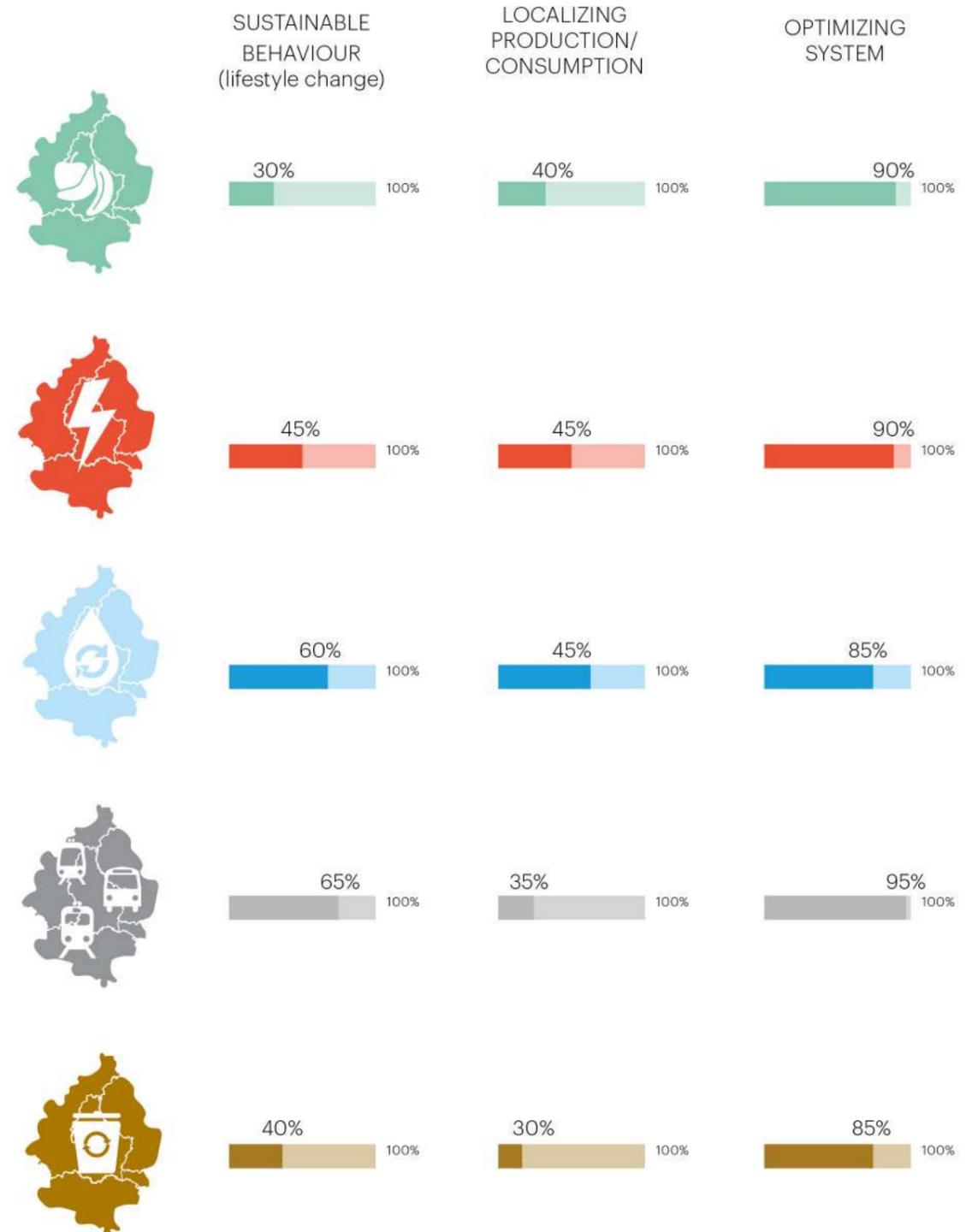
Citizens were actively involved in this process and together, citizen and expert committees wrote a new narrative for Luxembourg's spatial development. This narrative places ecosystems first and provides a true accounting for natural resources. Already in 2026, five years after the climate protests, decision-makers dissolved national borders and began to work from the bio-regional perspective. International green

networks lead the charge for the decisions as to where to densify and which land to re-purpose. Ruling out single land uses in dense areas, finite space and use of natural resources required an efficient, landscape-driven intelligent method of spatial planning.

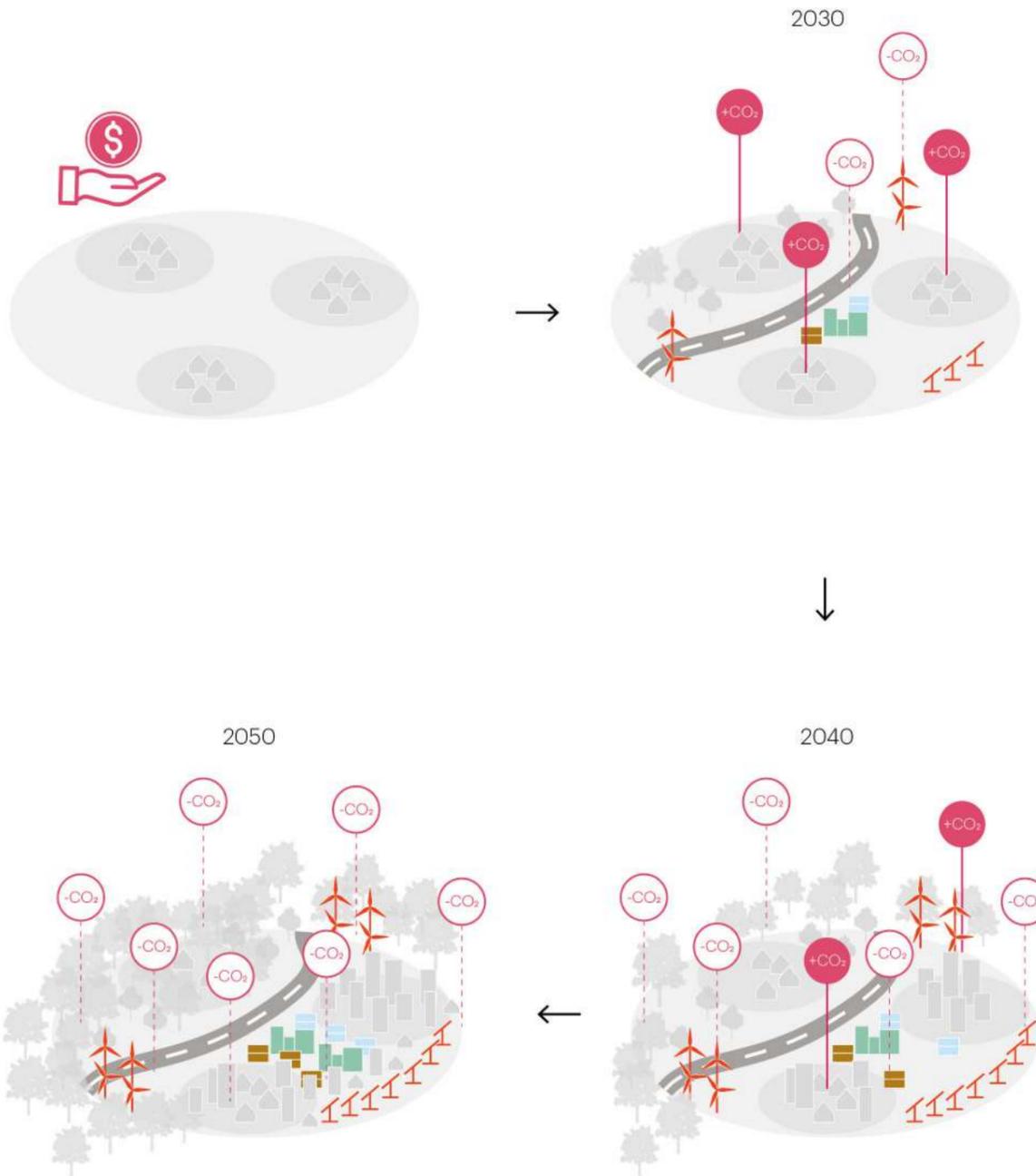
I see this in my work as a regional planner at the City of Luxembourg every day, from the briefs that I write for architects, and urban planners. These enforce the norm of only using surplus, bio-based materials for building construction. I also enforce this in the ecosystem service subsidy applications my colleagues and I assess, if a community wants to create a new co housing project.



The actions: Optimizing the system

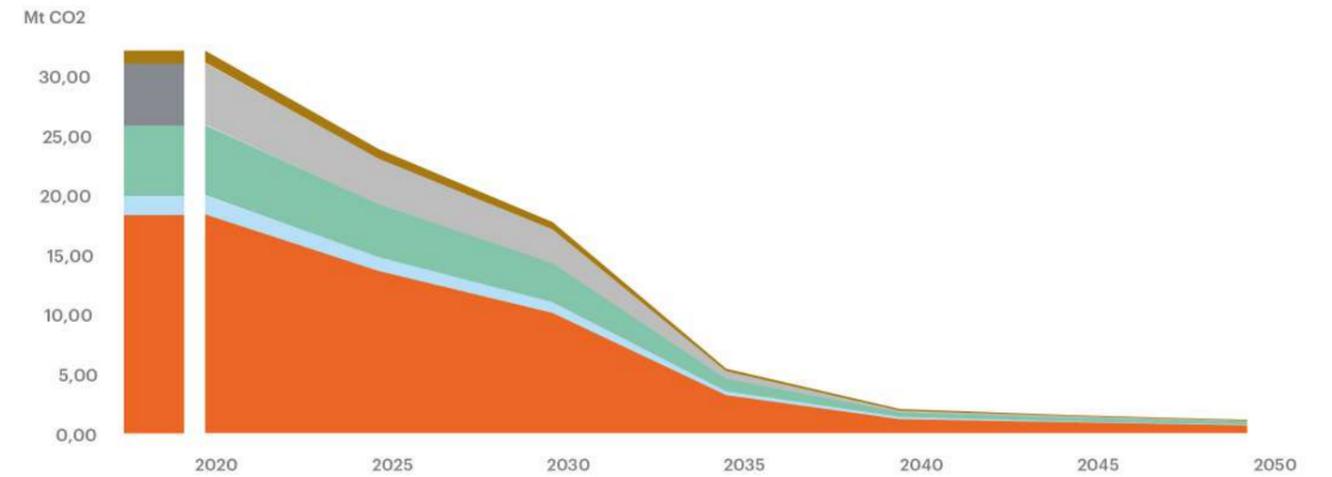


Phasing by 2050



TOTAL	32,0	23,8	17,6	5,4	2,0	1,5	1,1
Energy	18,3	13,6	10,1	3,2	1,2	0,9	0,7
Water	1,6	1,2	0,9	0,3	0,1	0,1	0,1
Food	5,9	4,4	3,2	1,0	0,4	0,3	0,3
Mobility	5,2	3,9	2,9	0,6	0,2	0,1	0,1
Waste	1,0	0,8	0,6	0,2	0,1	0,1	0,1
Year	2020	2025	2030	2035	2040	2045	2050

Reduction of CO2 (Mt) every 5 years

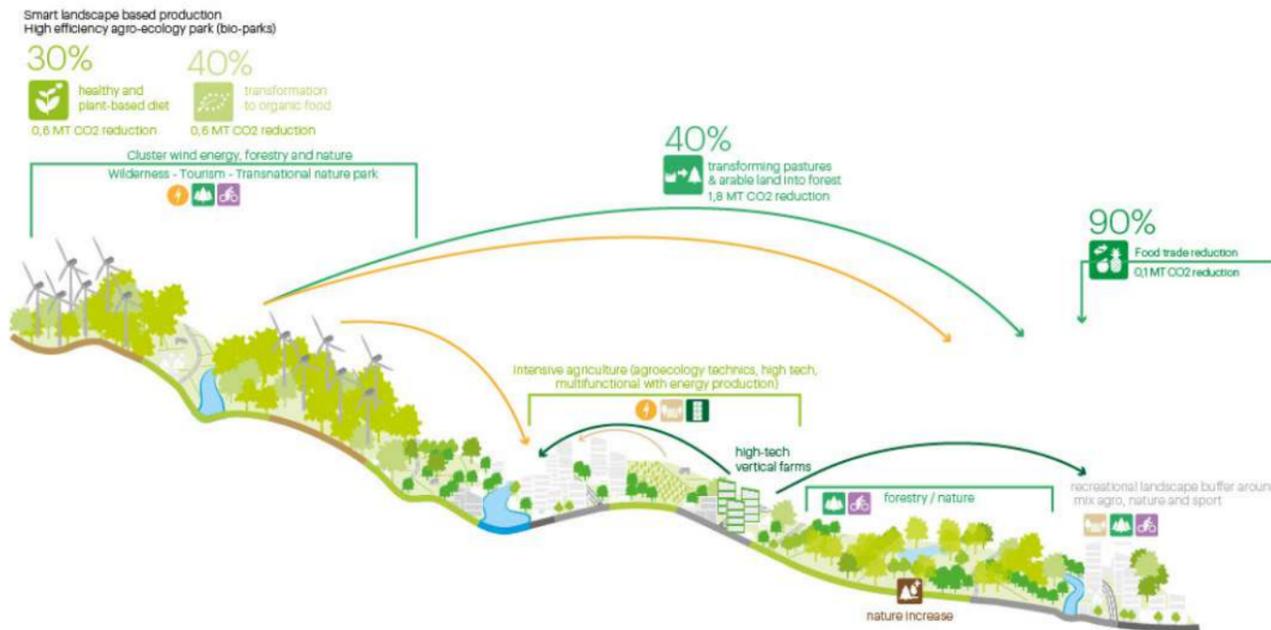


Phasing graph every 5 years

Food

My family and I, like most Luxembourgers, eat a local plant-based diet produced in and around cities in the southern part of the country. Half of our food is grown according to agro-ecological practices and the other half in high-tech facilities stacked upon the rooftops of our buildings.

The food policy council manages the spatial distribution of food production over the territory, ensuring that food production is in balance with ecosystems and landscape qualities.



Energy

Placing ecosystem services first in the spatial planning of the country, the energy system required adaptation to adapt to the landscape. It was amazing to see how quickly we could design this new strategy, by bringing together all national and local funds as well as the smartest of innovators. The transnational natural park in the north was perfect for harnessing wind power.

This area now houses all of Luxembourg's state of the art wind turbines. Solar roofs cover stacked high-tech food production. There are also a few locations distributed over the southern part of Luxembourg that are suitable for hydropower and geothermal energy, without disturbing the ecosystems.



Governance scenarios

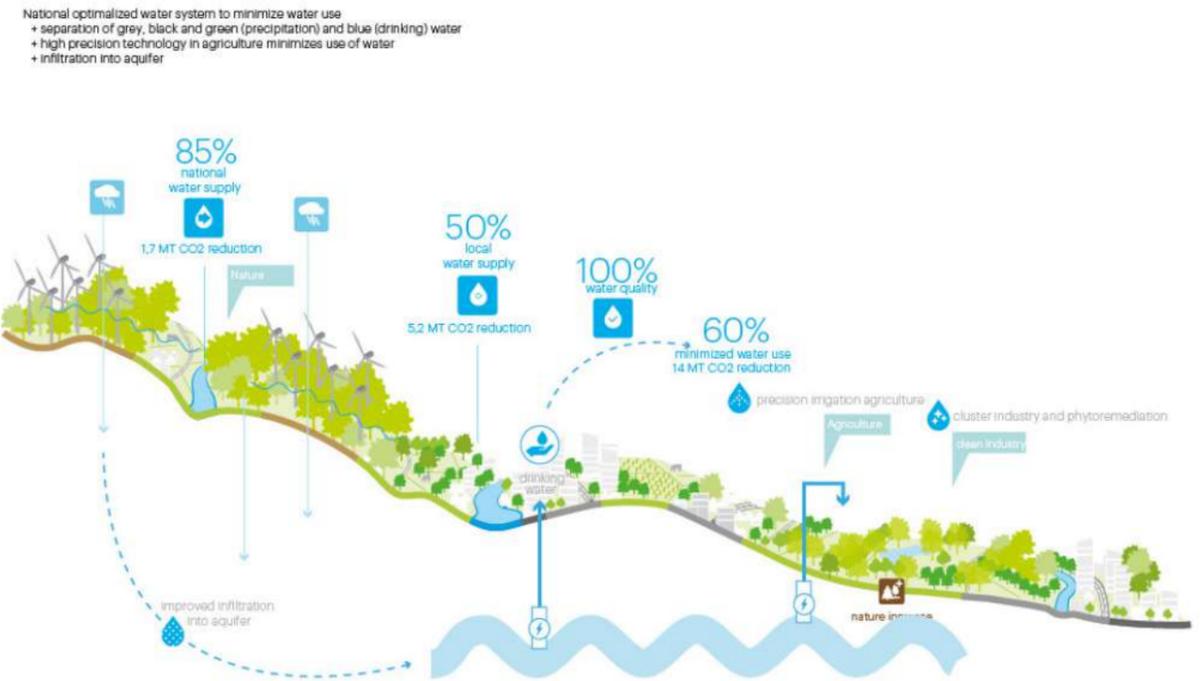
Geothermal energy 186

Beyond lux(e) - Stage O2

Water

Protecting ecosystems to the maximum, we're only using water that is not needed for the ecosystems. There is a national system in place for distinguishing between grey, black, and drinking water, in order to promote smart water use. During the yearly drought, I do water my

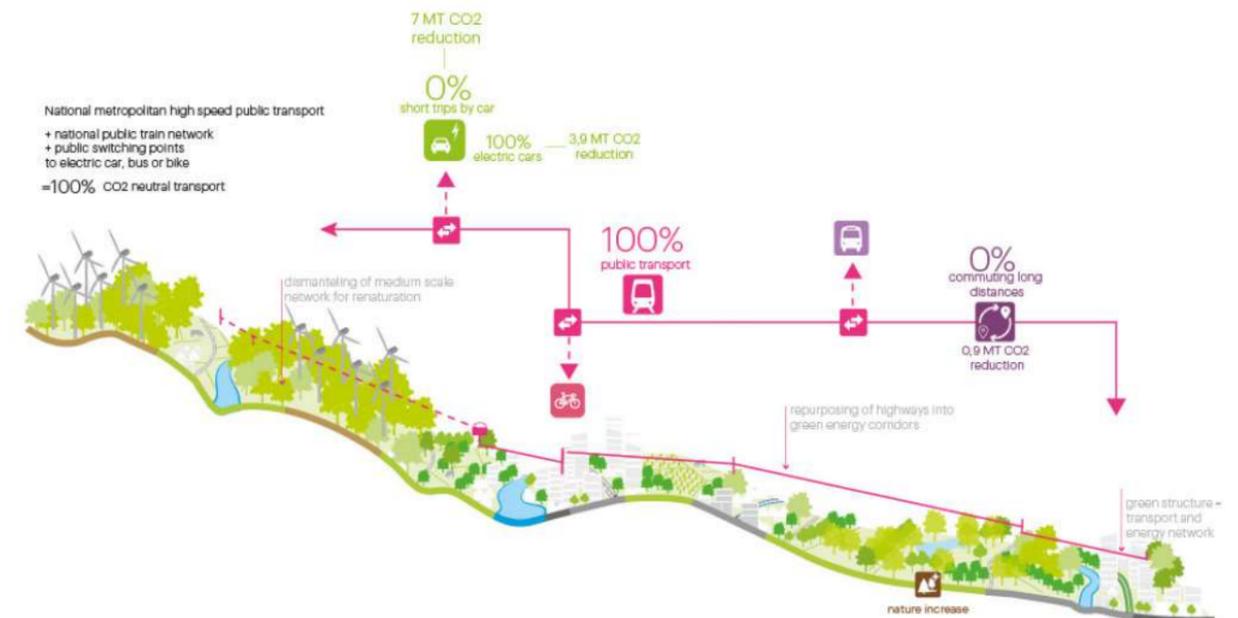
garden, but only with grey water. Businesses relying on water, for example for agriculture and manufacturing, use high precision technologies to minimise water use.



Mobility

My freedom hasn't been based on owning and driving a car for years now. Luxembourg has a well-functioning shared mobility system that based on emerging initiatives from the 2020s and implemented on a national scale. So now I use the "Lux on the move app" that helps me find the smoothest way to reach my destination - whether

it be a bike from one of the docking stations that you find all over the urban areas, to visit a client when I'm working at City Hall. Or, a train ride to the other side of the country and a short ride to an electric car loaned from the station to drive to the village where my mother lives.



Governance scenarios

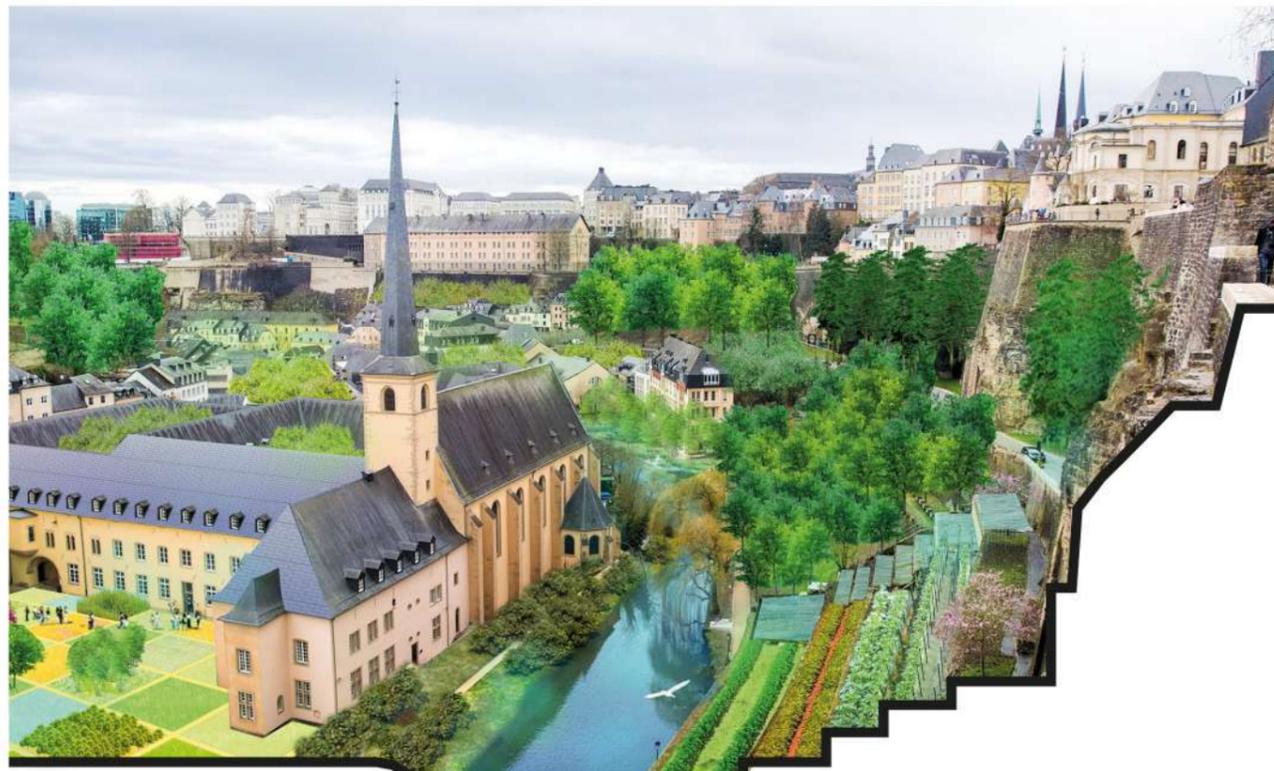
187

Beyond lux(e) - Stage O2

Waste

Materials are scarce and the reuse of consumer goods is vital to how we live now. I don't know how many times I've brought my 2020s keyboard in for repair at my local repair café. "Circular economy" is the major subject for my niece, who is studying economics at the University of Luxembourg.

Even my youngest is developing "repair skills" in primary school. As much as possible, we limit the production of non-recyclable waste. The little waste that we do still produce is recycled into all kinds of resources for other purposes.

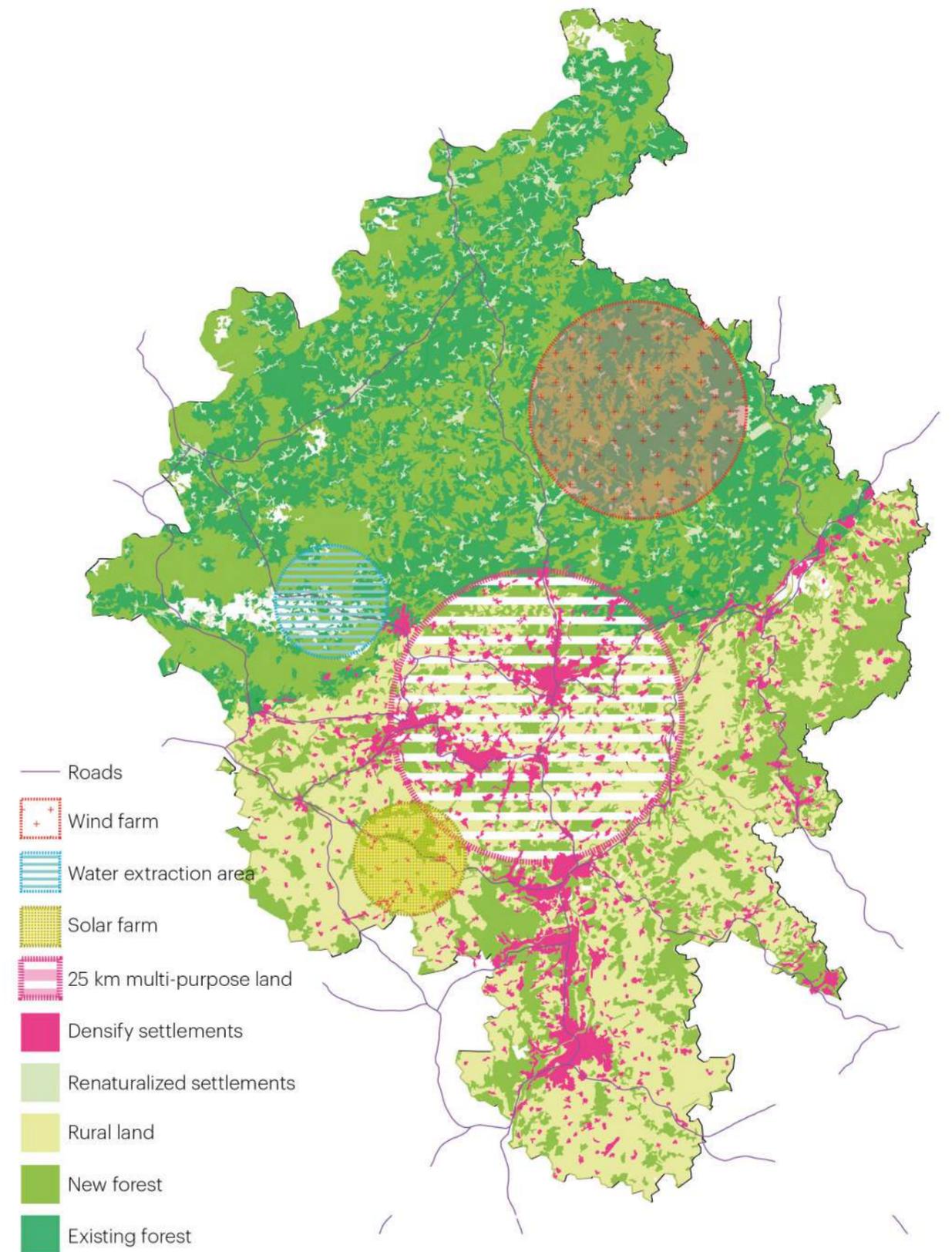


Governance scenarios

188

Beyond lux(e) - Stage 02

Vision by 2050

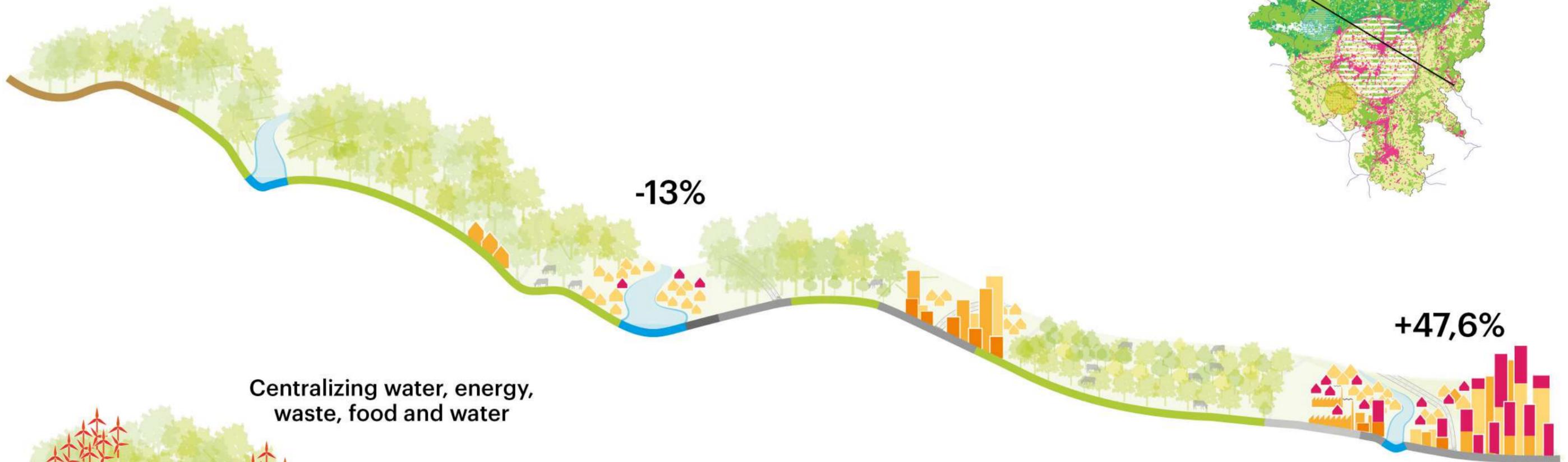
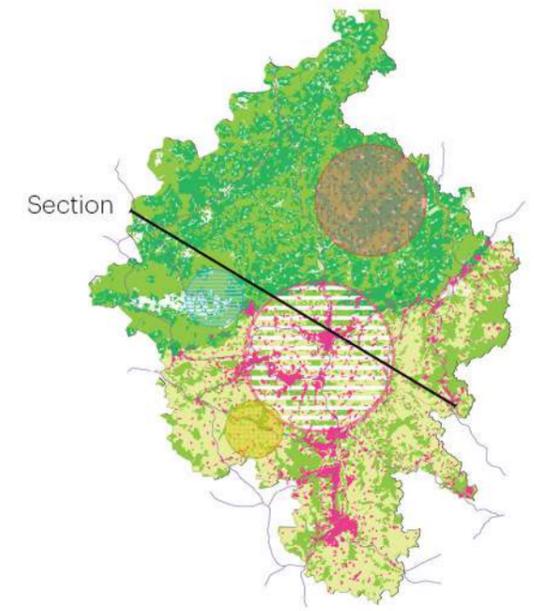


Governance scenarios

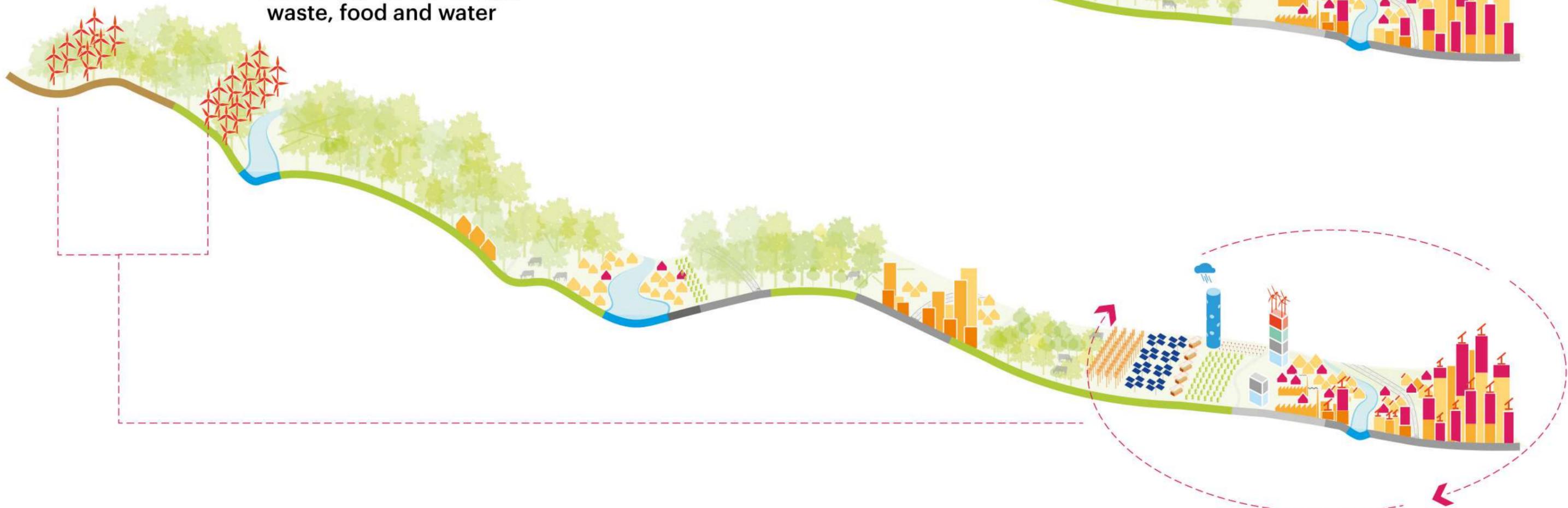
189

Beyond lux(e) - Stage 02

Growing South, Shrinking North



Centralizing water, energy, waste, food and water



Governance scenarios

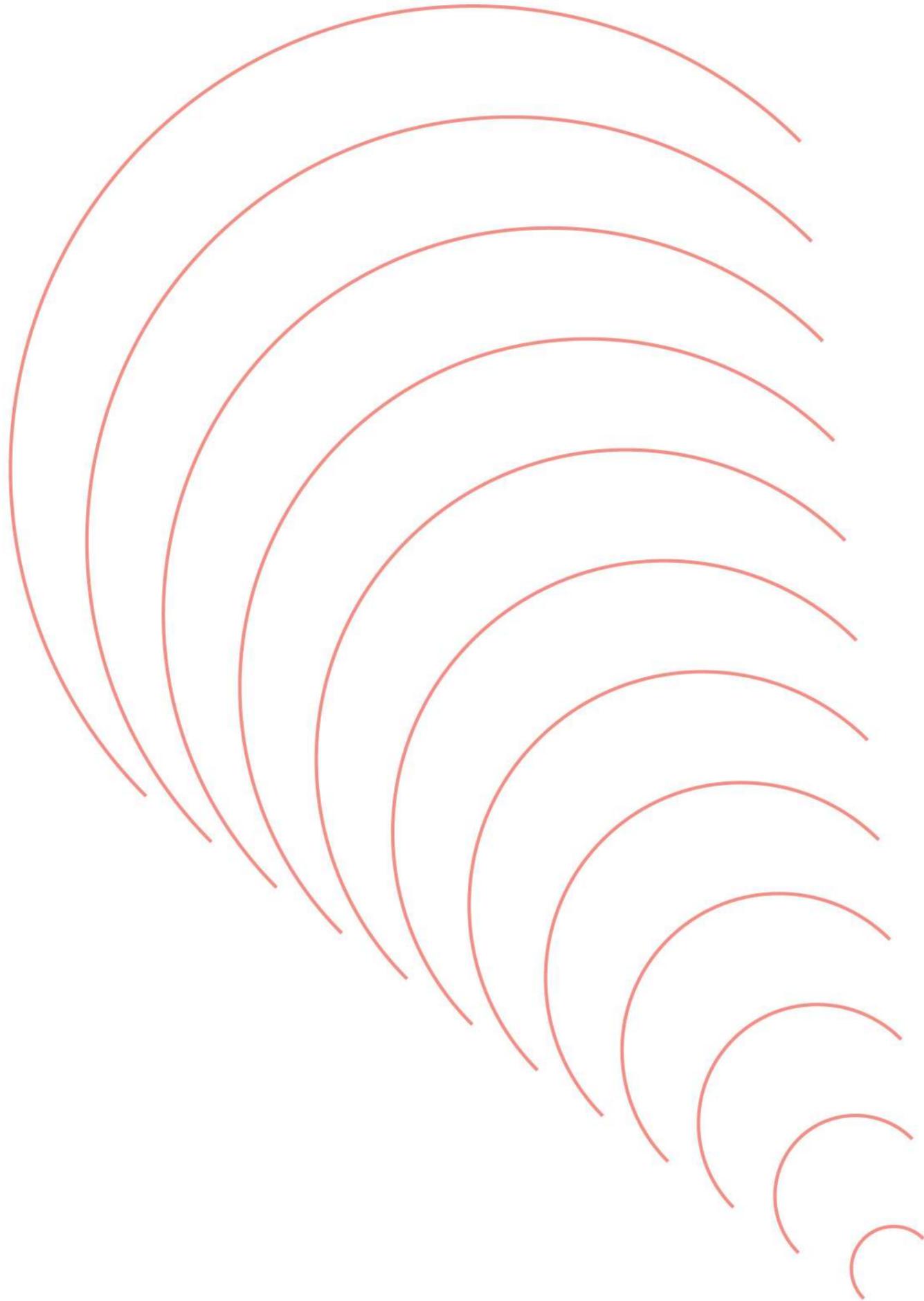
190

Beyond lux(e) - Stage O2

Governance scenarios

191

Beyond lux(e) - Stage O2



Lessons learned

Decarbonization reflection

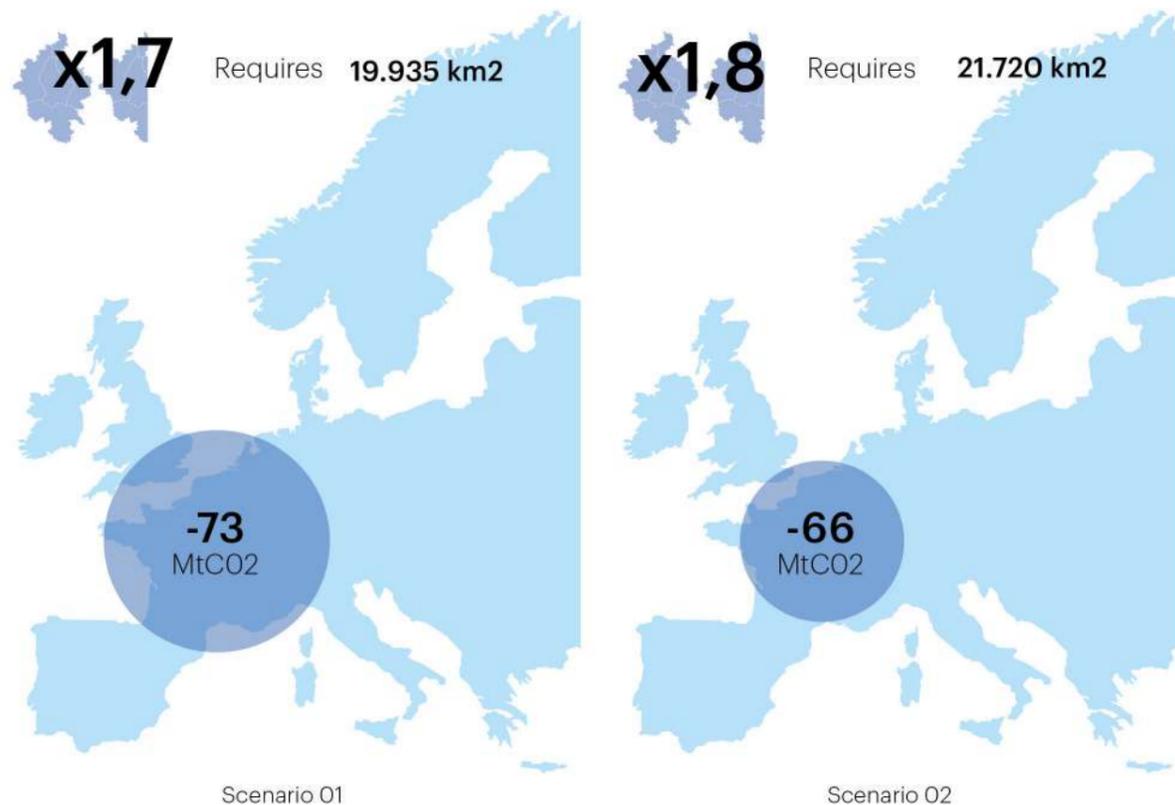
Each scenario reflects the governance approach on the measured sliders selection. However, in each action it is different from the others. Based on this, there are three main categories of actions: 1) lifestyle adaptation; 2) localize cycles; and 3) optimize through new technologies and efficiency. These three play an important role to lend coherence to every scenario. While in scenario O1, the sliders emphasize lifestyle adaptation, in Scenario O2, the strongest sliders emphasize optimization.

As concerns decarbonization matters, it is interesting that both scenarios reach zero carbon and beyond. However, we can see there are some slight differences with respect to the decarbonization strategy in each scenario.

Scenario O1 achieves decarbonization through lifestyle adaptation. This, as we as reflected on governance, will demand a slow and steady change over time. Therefore, the zero carbon transition won't happen in an advanced way until

policy implementation takes place. Here themes such as food and energy have considerable influence. Reducing consumption has an impact on co2 emission reduction. However, other themes have a larger impact on other actions.

Comparing both scenarios, it is clear that the fact that both achieve zero carbon, or even beyond, does not mean they are both the most (re)generative proposals. Therefore, decarbonization does not equal (Re)generation. We must pursue a governance and spatial reflection, and define (Re) generation as a target in the final vision.



Governance reflection

The two scenarios reflect two governance extremes that can bring the Luxembourg functional area towards a zero carbon, regenerative, and inclusive future. They each have their own particular characteristics and logic to employ along the way, demonstrating that the Ministry of Energy and Spatial Planning can select from at least two options that require different roles from the Ministry and different governing structures in collaboration with other actors.

Scenario 1 illustrates that a simple tax change can lead to an entirely different production and consumption model for the country. This governance intervention creates the conditions and supports opportunities that were already developed, such as repair cafes, energy cooperatives, the wood cluster, urban community gardens, fab labs, shared mobility options. These emerging initiatives will rapidly become dominant practices because they are financially more attractive than fossil fuel based options. This allows local communities to self-organize and build a robust cooperation across a coalition of municipalities. It boosts the local identity and creates strong social networks in which people take care of each other. However, the strong entrepreneurial role that communities and businesses take in this scenario can also result in inequalities, as the free market principle is still the dominant model. Those who cannot compete, run the risk of being left behind. In every coalition of municipalities, different kinds of solutions will thrive, creating a disconnect on a national level with no economies of scale.

Scenario 2 illustrates that a strong national government can bring all the expertise together and determine the best means of regenerating the ecosystems of the functional area. This governance intervention creates coherent and well-designed solutions that strengthen the landscape. For instance, in rewilding the Ardennes, agriculture can improve the biodiversity, rivers and streams of potable water. In this scenario, ecosystems no longer suffer from human intervention but become more robust through intentional and thoughtful coordination. Citizens feel that the government takes good care of them by including them in understanding why such interventions are in society's best interest in the long term. This builds a sense of belonging and people will be proud to be part of the Luxembourg movement. Significant investments to redesign the mobility, food, energy, waste, water systems are possible because of economies of scale.

However, national government-dominated approach can also disempowering citizens and entrepreneurs who were already working on local solutions, while the societal divide between pro and contra government grows. This is a critical issue to attend to.



Scenario O1



Scenario O2

Spatial reflection

The two scenarios illustrate how extreme governance options result in extreme scales of spatial organization. Strong economic incentives that discourage long distance transport of people and products, and at the same time encourage human labour (Scenario 1), support bottom-up entrepreneurship and local spatial organization. If, on the other hand, governance goes far beyond incentives and is to direct a spatial optimization of the economy (Scenario 2), the government itself will act as an entrepreneur and will actively reorganize land use, networks and settlements on a territorial scale.

The landscape will gradually change as spatial organizational changes take place. In the first scenario, the economy is organized on the household and community level, with the main spatial grain size being the (rural) village or (urban) quarter. Each will have its own food market, power plant, repair shop annex recycling station, transport / logistics hub and maybe even its own water reservoir. Each municipality or administrative area's entrepreneurs and public services, circular economy initiatives, and local production solutions adapt by and for the local actors, as they come from the existing assets of each territory.

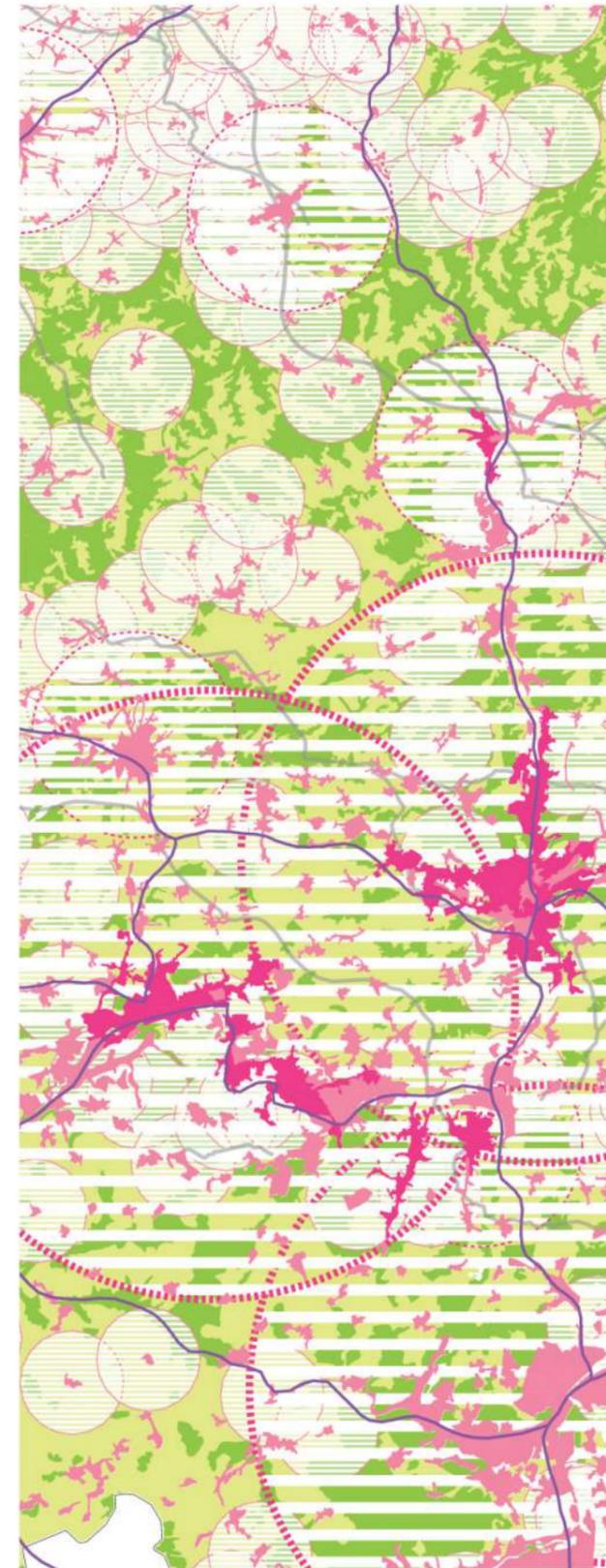
Territorial and cultural changes will largely determine the spatial expression of these local economies, but specialization, excellence, and economies of scale will be limited.

This model (Scenario 1) applies the production of food and energy at a local scale (around and within cities), optimizing the landscape for self-sufficiency. The circular economy links the food, waste, and energy sectors at community or the administrative region scale, reducing waste and minimizing imports. They inspire a variety of farming land-uses within urban settlements surroundings: food forests, and various polycultures, which provide added benefits for water infiltration and soil regeneration. However, in Scenario 1 polycentric organization distributes the urban settlements and is therefore less efficient in terms of land use and logistics. This structure is also more constraining for biodiversity and ecological corridors. This scenario therefore tends to economic and spatial mediocrity and uniformity.

The second scenario exploits territorial and cultural differences to extract as much as possible from available resources. With economies of scale and excellent performance as leading principles, sublime (but in itself monotonous) large-scale

urban, rural, and natural landscapes will emerge. For example, these include large wind turbine parks with eco-forestry as a sub layer in the Ardennes territory or bio-agricultural parks with solar energy production. This will inevitably lead to an economic organization on a higher level of scale (with partnerships between the countries of the greater region), and the transport of people and products over longer distances.

The urban structure is more optimal with a less space-consuming organization, and equipped with a highly efficient mobility system (high-speed train from Metz to Luxembourg). This approach also helps to recreate large areas of wildness, essential to European natural corridors, intelligently adding the benefits of these spaces: eco-forestry to provide building materials, facilitated water infiltration, local nature tourism. This scenario gives Luxembourg an organization with more contrasts (urban/nature), fading out the current mosaic of Luxembourg's rural landscapes.



Scenario 01 map



Scenario 02 map

Ecotopia scenario

Lux+ by 2050?

Phasing

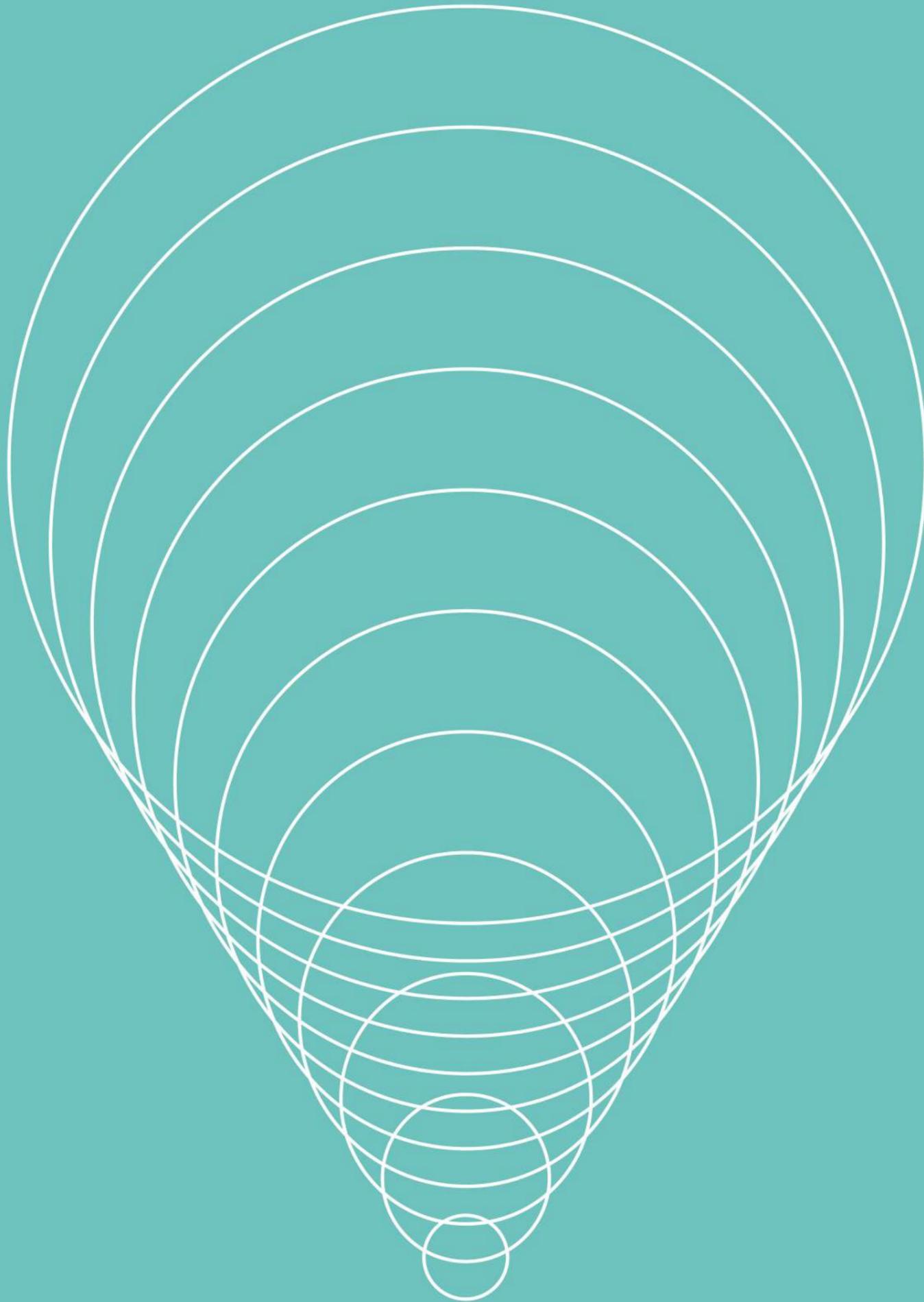
Balancing growth

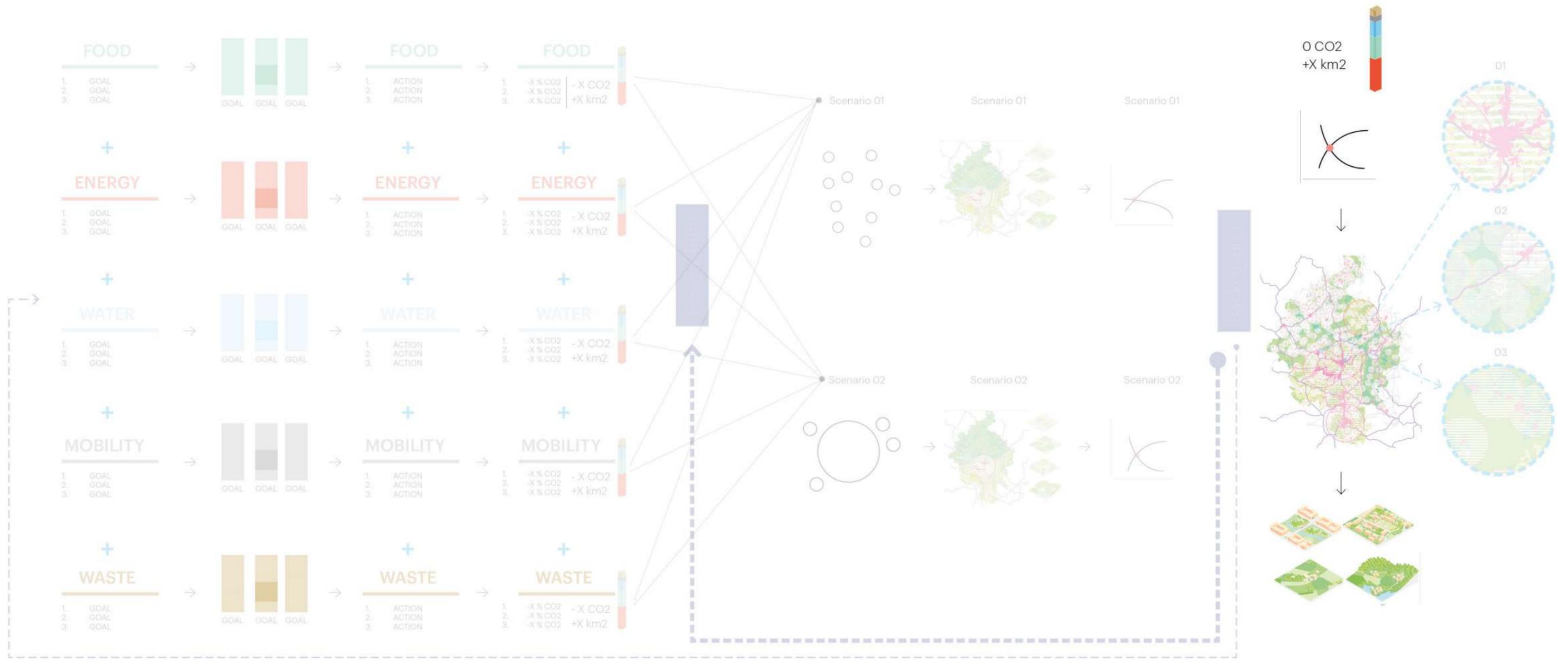
Balancing cross-border dependency

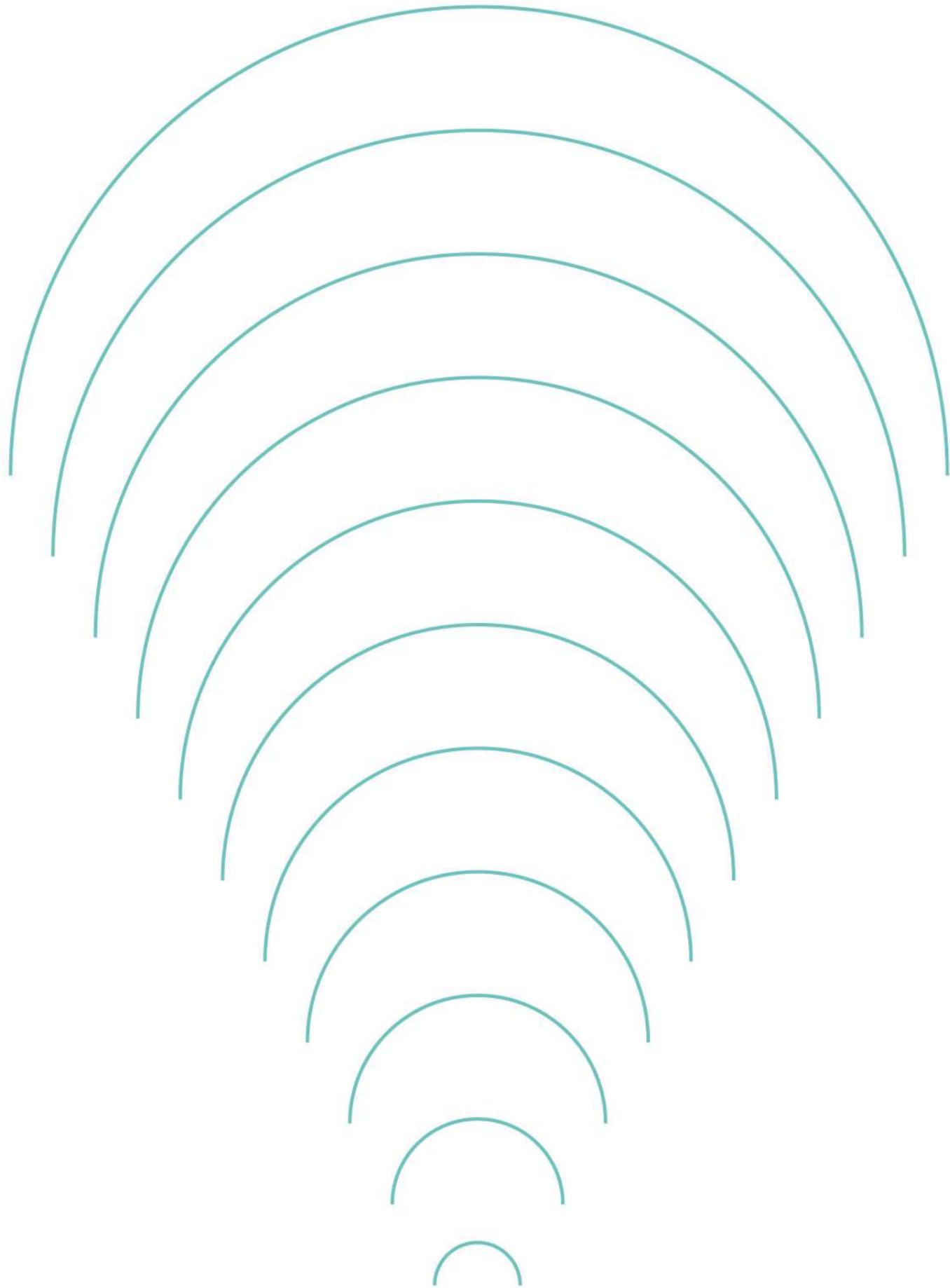
A multilayer approach

The benefits

6







Lux+
by 2050

9 Principles for Ecotopia

1

Luxembourg connects people with nature to ensure peoples mental and emotional well-being.

2

Luxembourg' settlements are rethought to provide room for nature and healthy urban growth.

3

Luxembourg prioritizes local connections over long distance ones by collaborative building use and sharing facilities.

4

Luxembourg cities will generate richer soil cover and become healthy environments for its inhabitants

5

Luxembourg natural areas in the north will be renaturalized and contribute to energy production and water buffering

6

Luxembourg rural areas in the south will produce healthy foods and produce energy while cleaning water.

7

Luxembourg will first localize, then collaborate with neighbouring coalitions of municipalities and as a last resort import.

8

Luxembourg's food-, energy-, mobility- and waste systems are designed to be circular and contribute to the local economy.

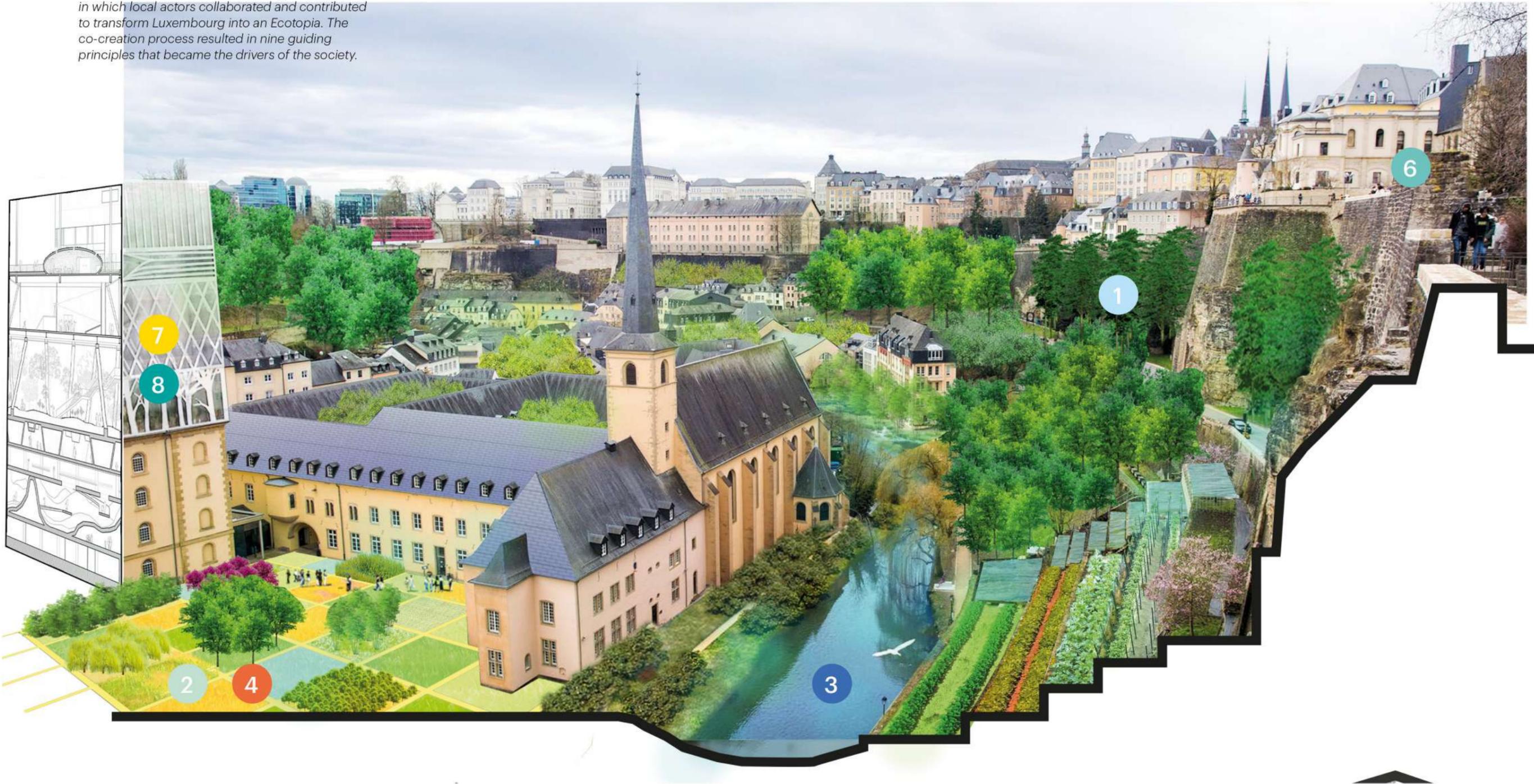
9

Luxembourg's cross-border bioregion supports bottom-up initiatives around seasonality, soil regeneration, nature friendly and balanced land-use to promote collaborative economy

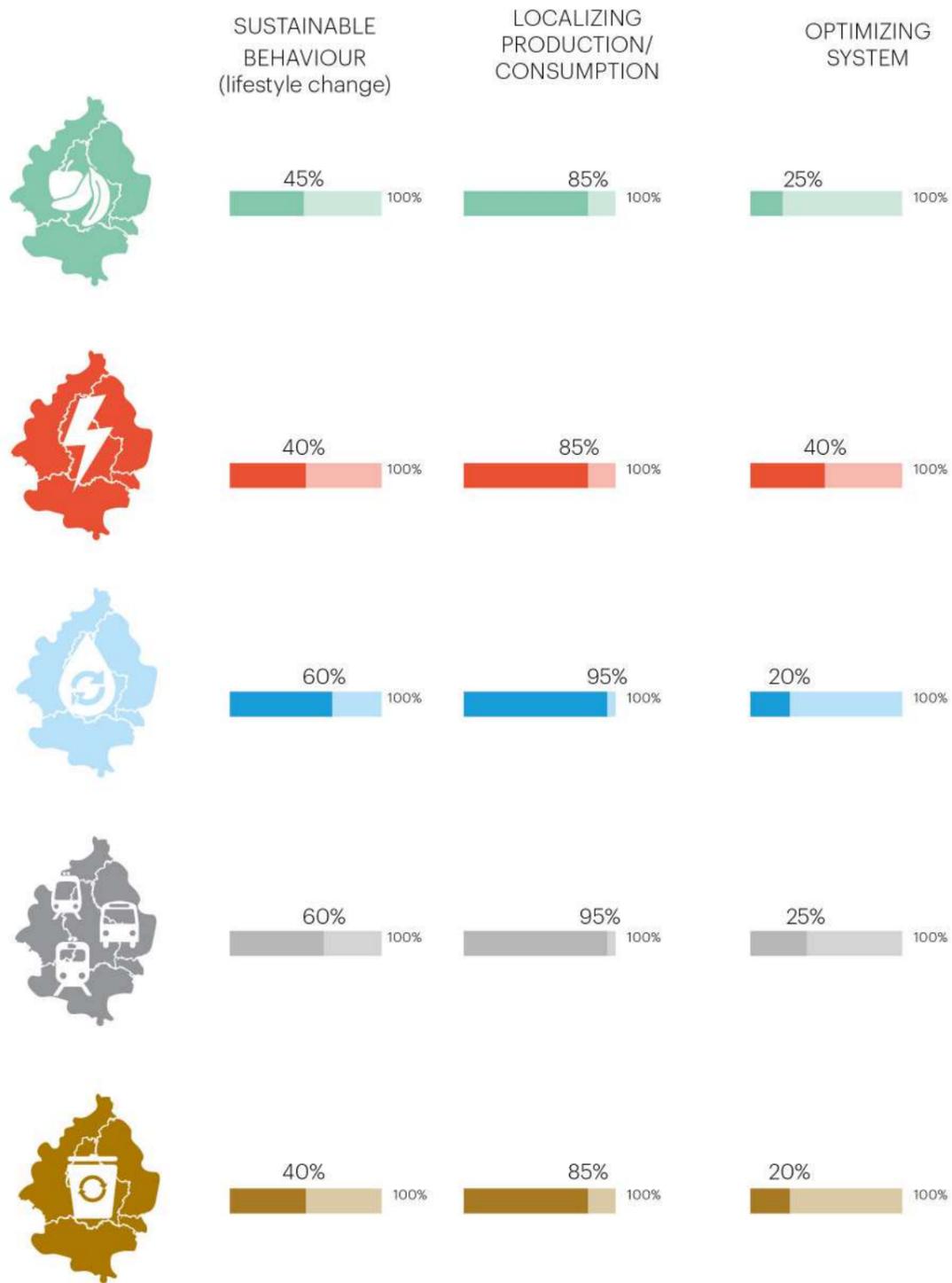


What is like lux+ by 2050?

Who could have imagined that the "ReThink Luxembourg" campaign of 2025 was that successful? It completely changed how we use our landscape and our local resources! The ReThink-tank existed of a group of experts from all domains and from all parts of the country. The experts facilitated a participatory process based on co-creation principles informed by the state-of-the-art knowledge on the ecological transition. This led to a flexible but guiding process in which local actors collaborated and contributed to transform Luxembourg into an Ecotopia. The co-creation process resulted in nine guiding principles that became the drivers of the society.



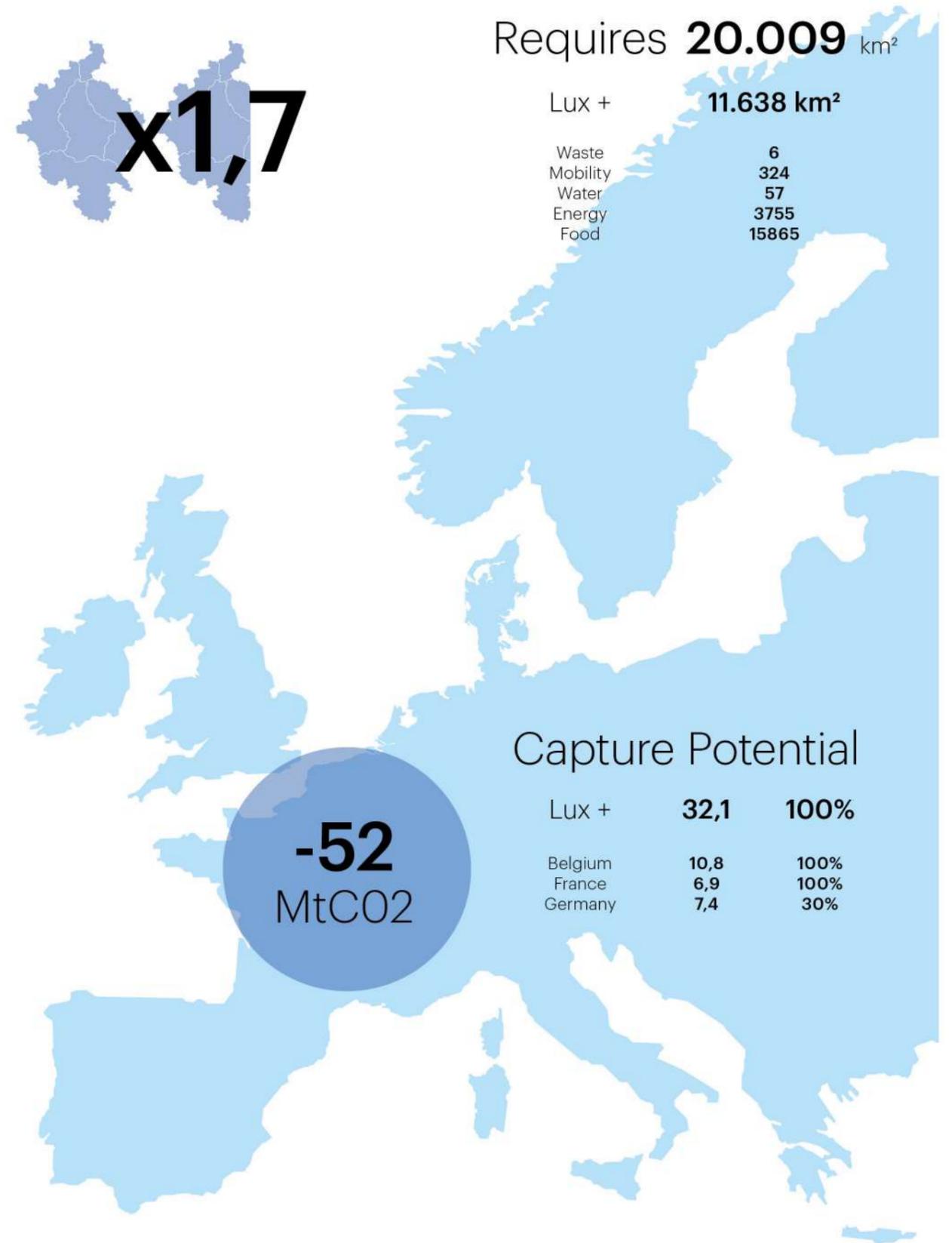
The actions



Ecotopia scenario

208

Beyond lux(e) - Stage 02



Ecotopia scenario

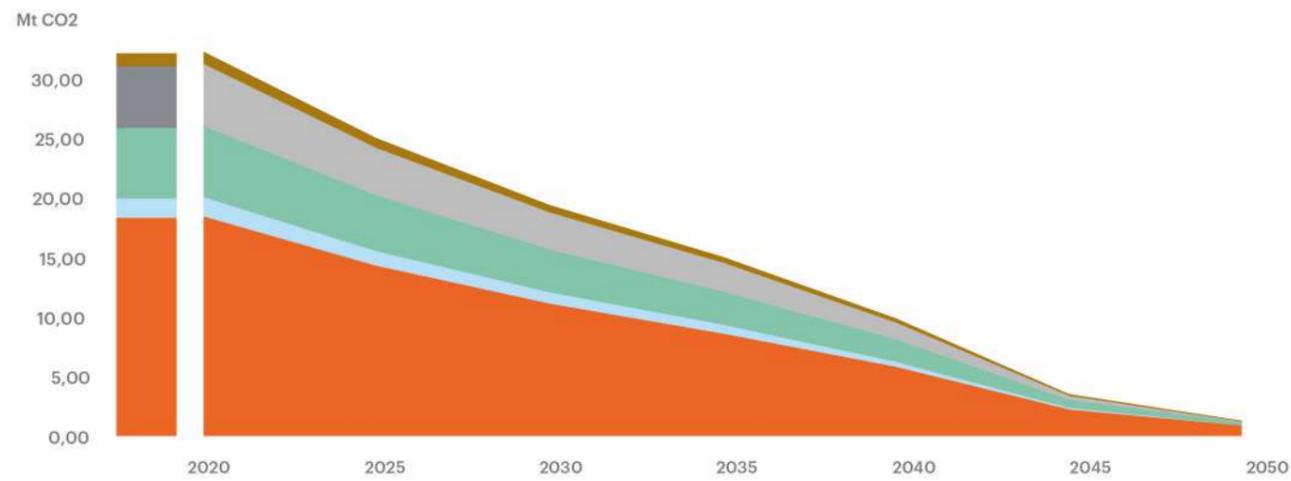
209

Beyond lux(e) - Stage 02

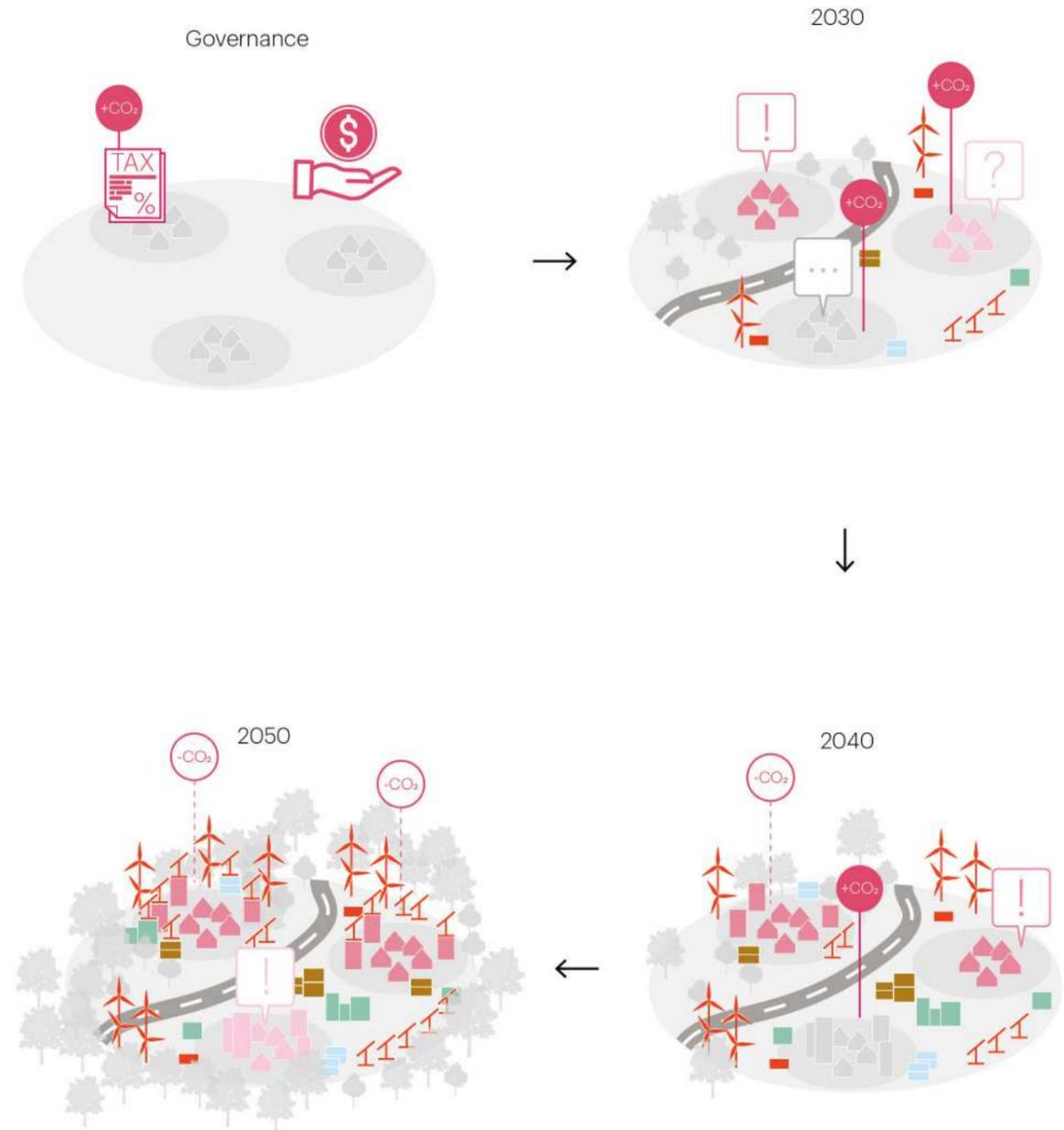
Phasing by 2050

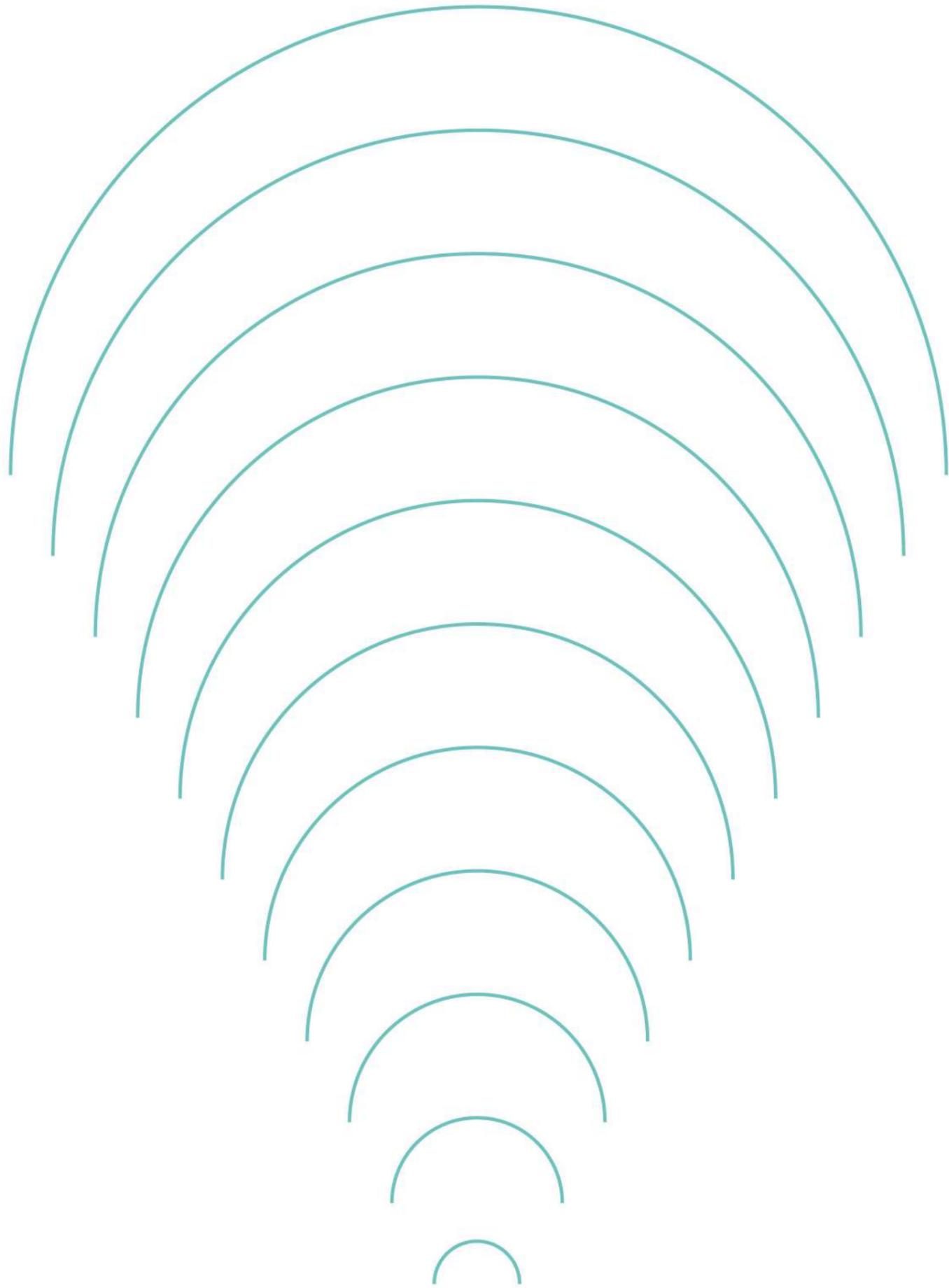
TOTAL	32,0	24,8	19,2	14,9	9,8	3,5	1,3
Energy	18,3	14,2	11,0	8,5	5,7	2,2	0,9
Water	1,6	1,2	1,0	0,7	0,5	0,1	0,0
Food	5,9	4,6	3,5	2,7	1,9	0,7	0,3
Mobility	5,2	4,0	3,1	2,4	1,5	0,3	0,1
Waste	1,0	0,8	0,6	0,5	0,3	0,1	0,0
Year	2020	2025	2030	2035	2040	2045	2050

Reduction of CO2 (Mt) every 5 years



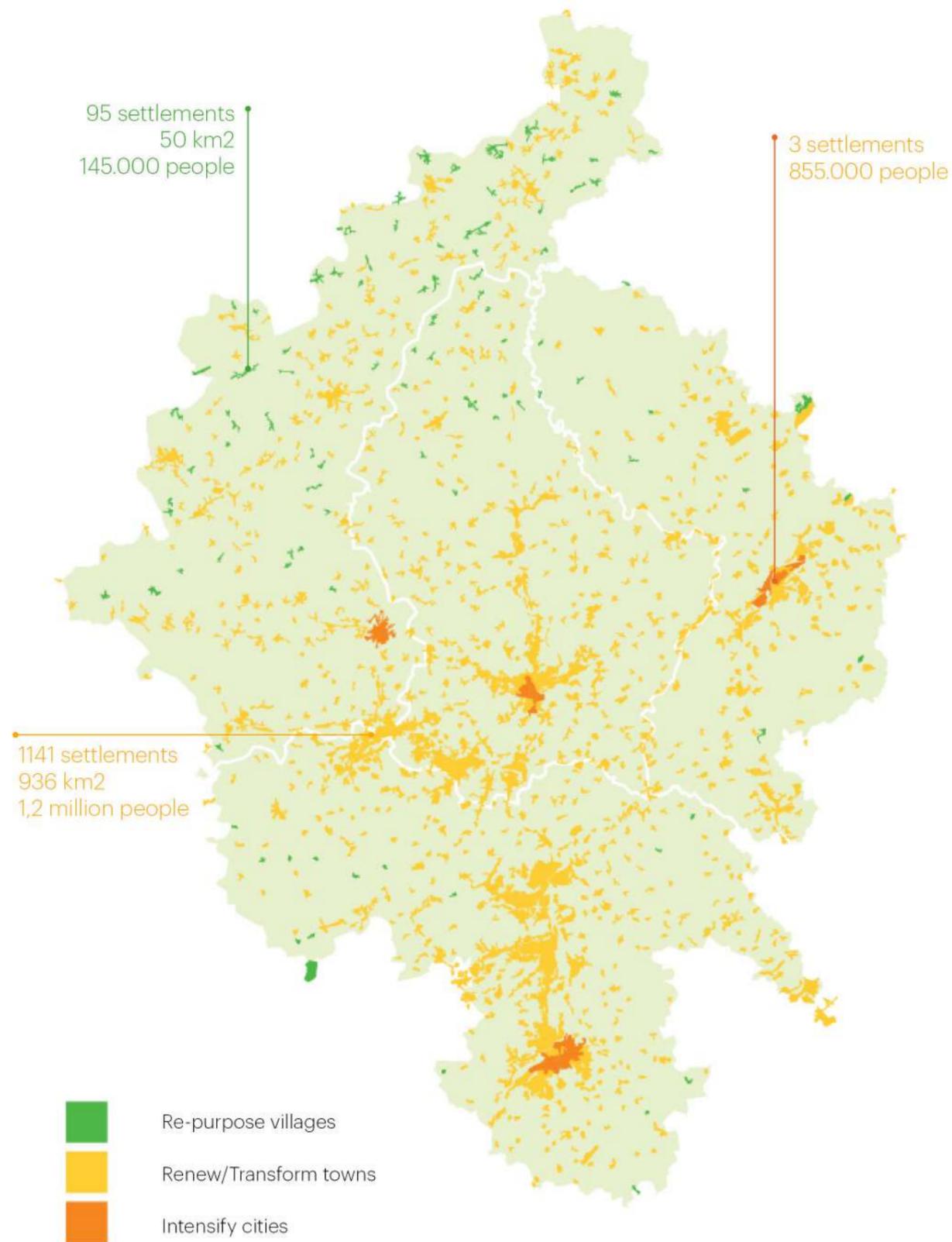
Phasing graph every 5 years





Balancing
growth

Balancing urban growth

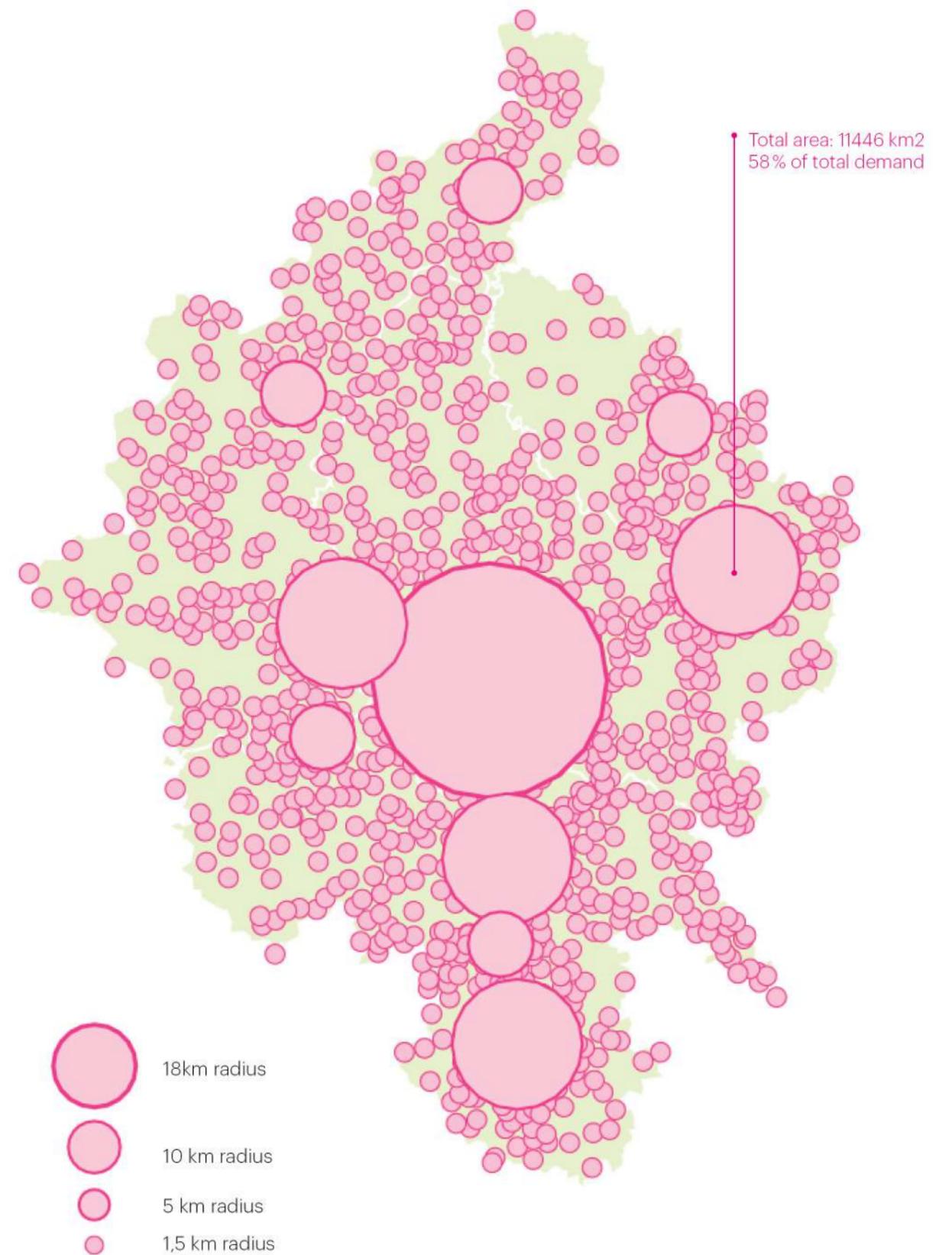


Ecotopia scenario

214

Beyond lux(e) - Stage O2

Localizing 5 themes based on proposed density



Ecotopia scenario

215

Beyond lux(e) - Stage O2

Balancing urban growth

In order to balance urban growth according to conclusions based on the analysis, the three strategies relate to current conditions of settlements.

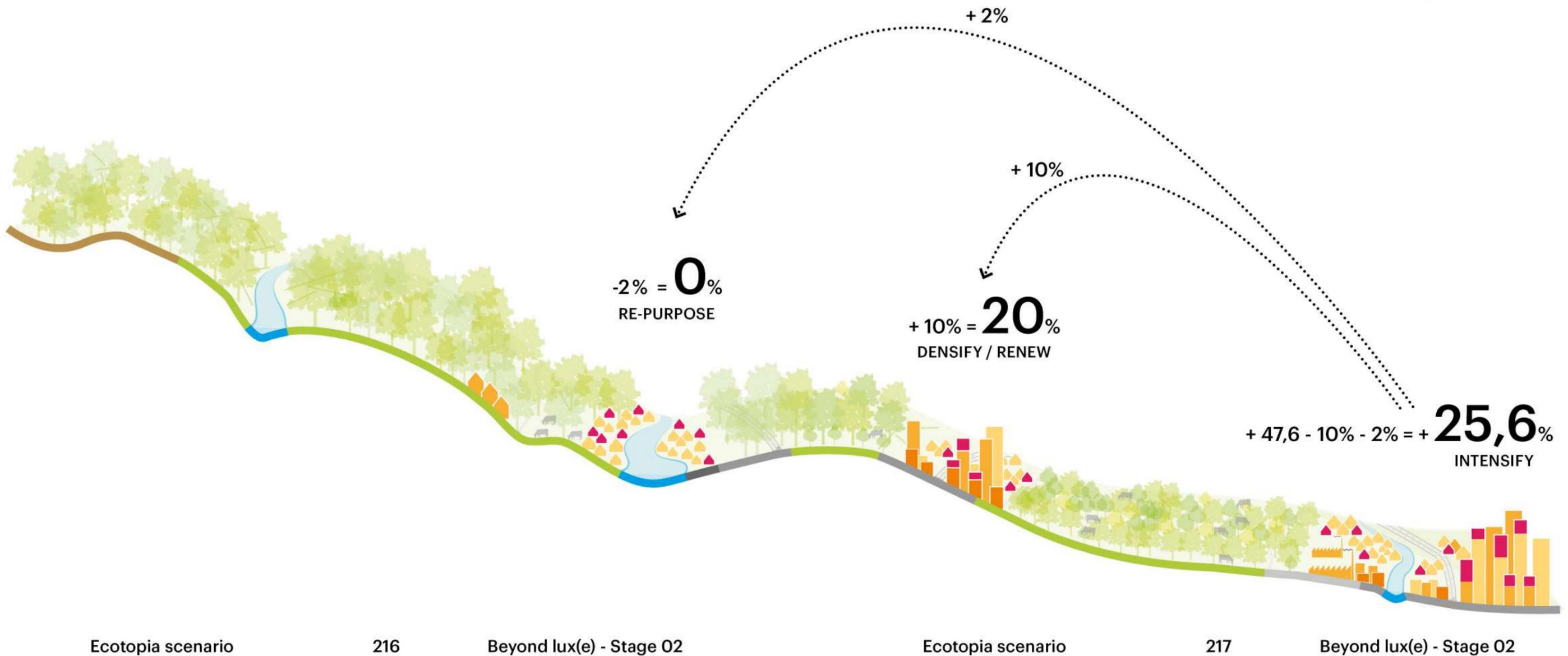
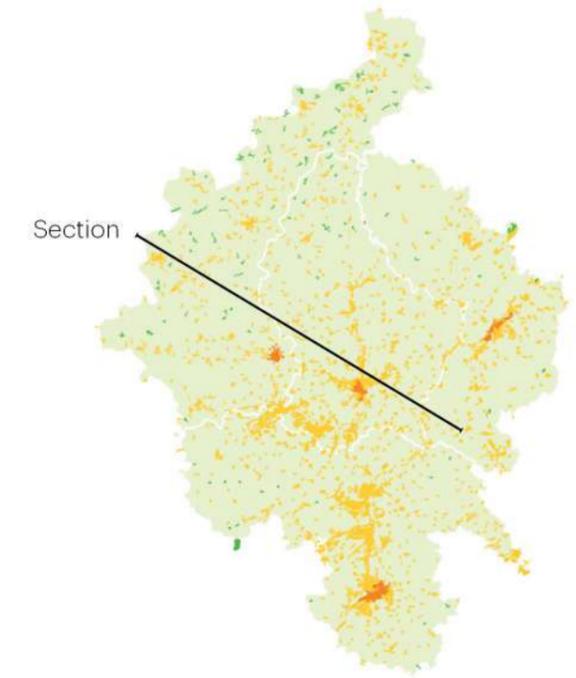
The proposal is based on:

- Intensifying main cities: Luxembourg, Metz, Trier and Arlon. This supports healthy urban living. This produces more green open spaces, more liveable spaces, and ensures more human-friendly systems within the city.

- Renew/densifying the majority of the settlements of the region. These areas absorb some of the growth from big cities to address the functional area's mono-centric composition. The intervention supports denaturalized vacant spaces, the transformation of urban rural areas

into more green spaces, and collaborative clusters of settlements.

- Re-purposing land: surrounding a small portion of settlements are rural and/or natural environments. They could become important areas of opportunity for re-purposing as facilities for more recreational or productive functions within natural areas. In the long-term, they could also be repurposed as wild landscapes.



Ecotopia scenario

216

Beyond lux(e) - Stage O2

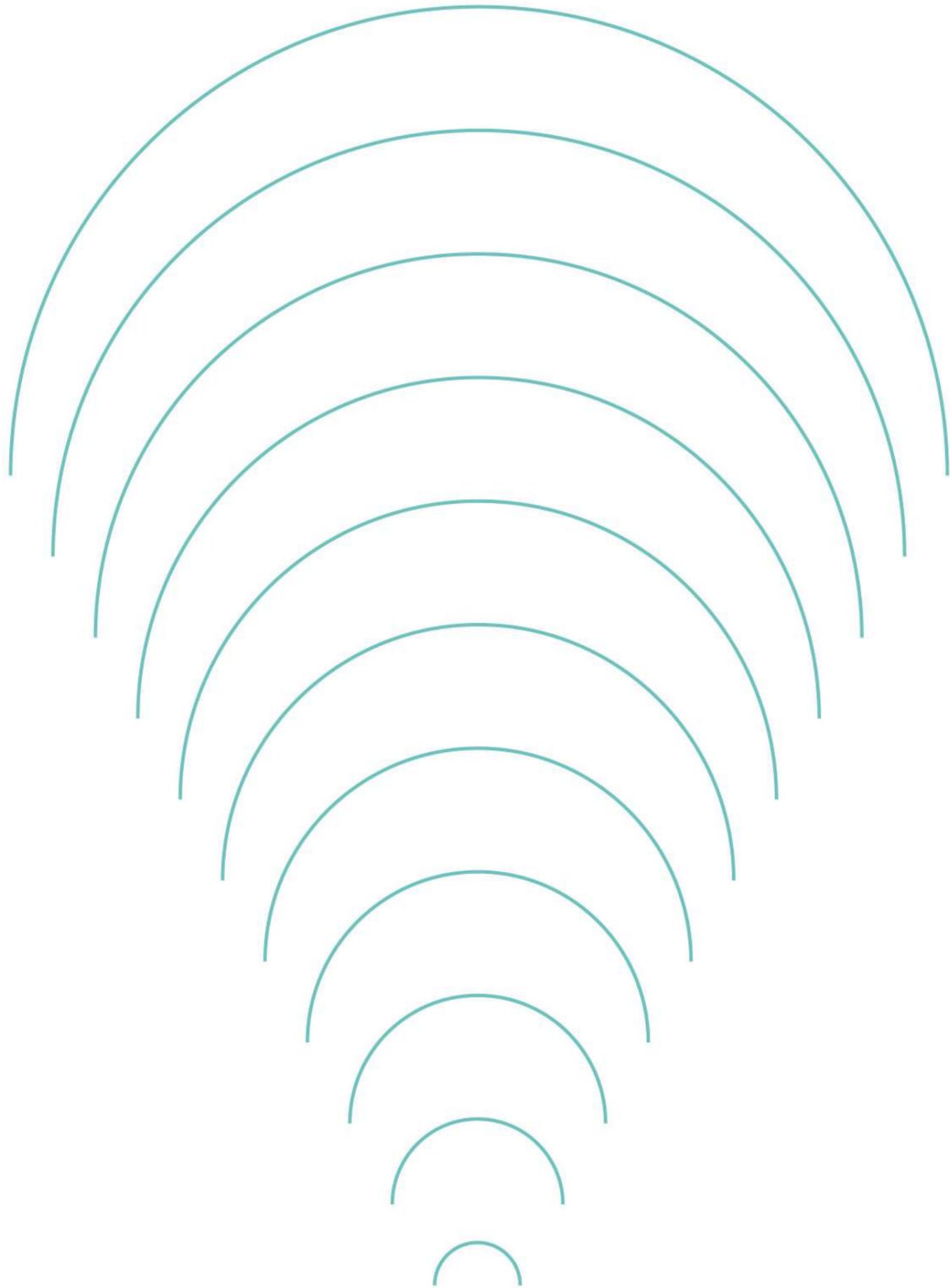
Ecotopia scenario

217

Beyond lux(e) - Stage O2

Balance urban growth towards less centralized region





Balancing
cross-border
dependency

Back to the future: Francois

Looking back on the effects of each scenario from 2050, is Arlon city planner, Francois Bernard.

Presenting alongside Rachel Hoffmann at ISOCARP 2050 in Vancouver, Canada, Francois shares his insights on how Lux (+) has catalyzed positive change for the functional area and beyond.

In the pages that follow, we explore, through Bernard's eyes, how Lux(+) has changed how people live, work, and play in 2050.



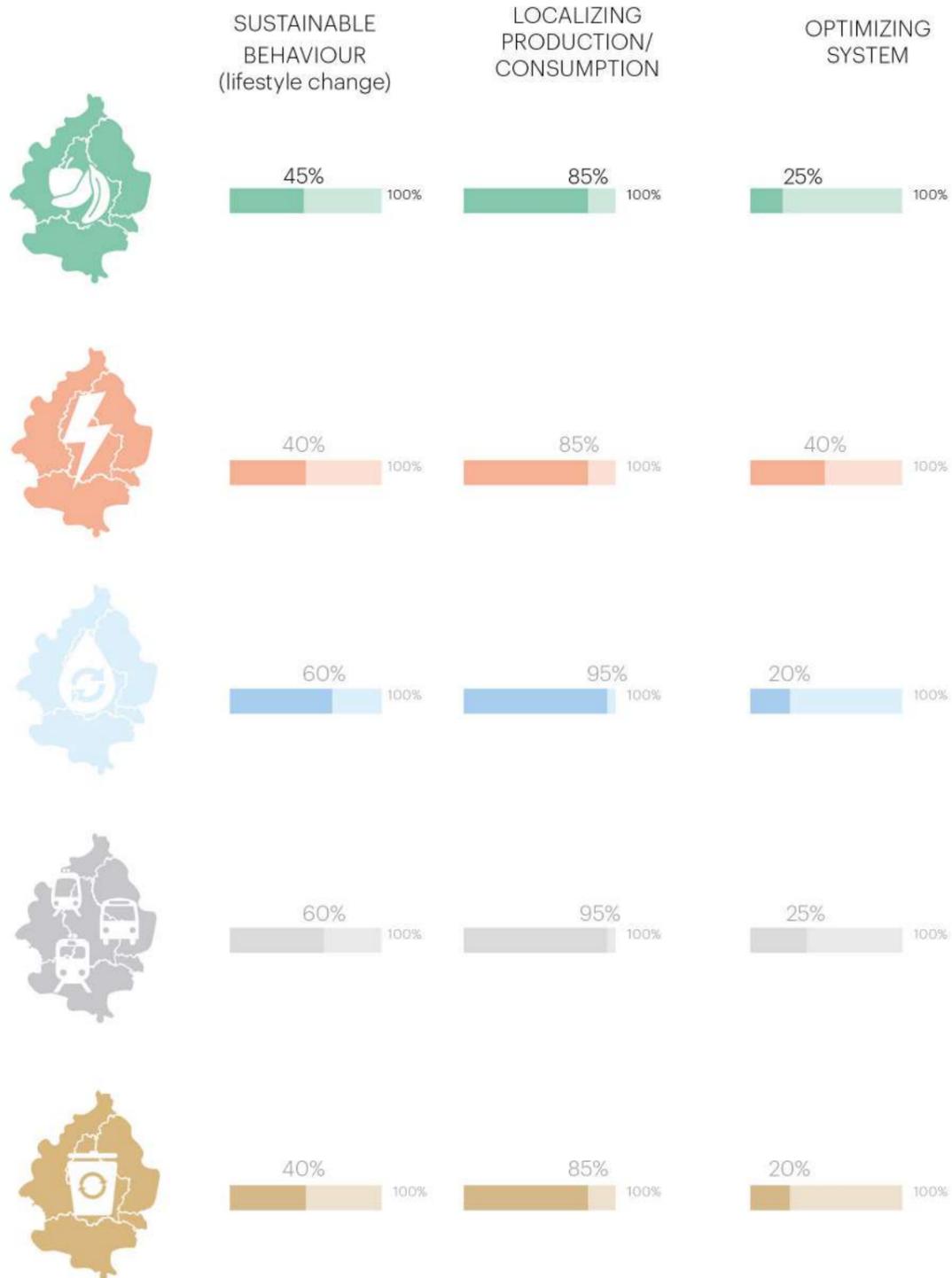
Ecotopia scenario

Beyond lux(e) - Stage 02

Ecotopia scenario

Beyond lux(e) - Stage 02

Food



Demand
15865km²



Agricultural Land
15865km²

Proposed
16348km²



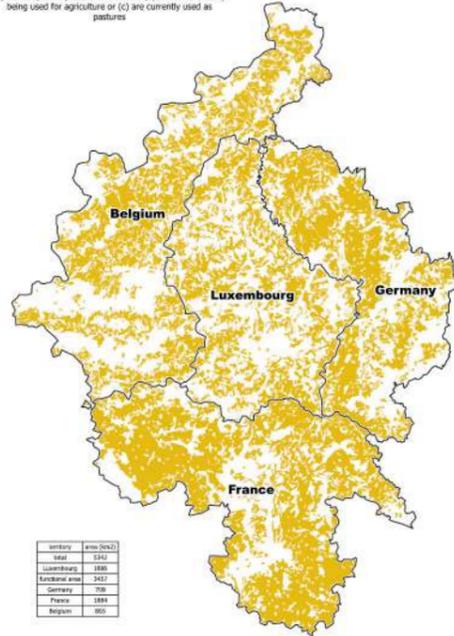
Vertical Farming
7760km²
970 km² x 8 levels

Multi-purpose
8588km²

Suitability areas

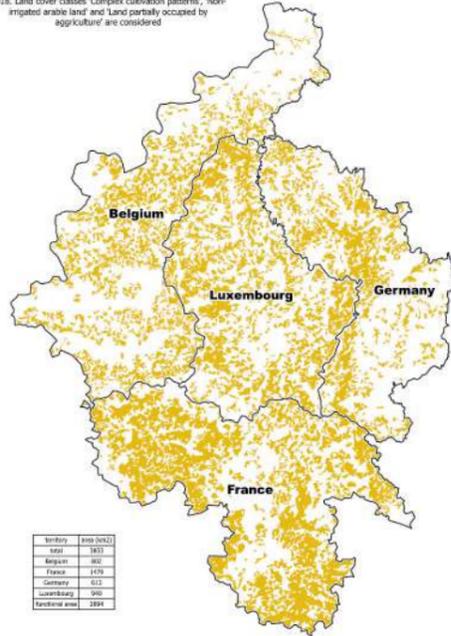
Production around urban centre
Total suitable area: 3457 km²

This map shows areas within 5km from urbanized areas that (a) are not part of protected areas and (b) are either already being used for agriculture or (c) are currently used as pastures



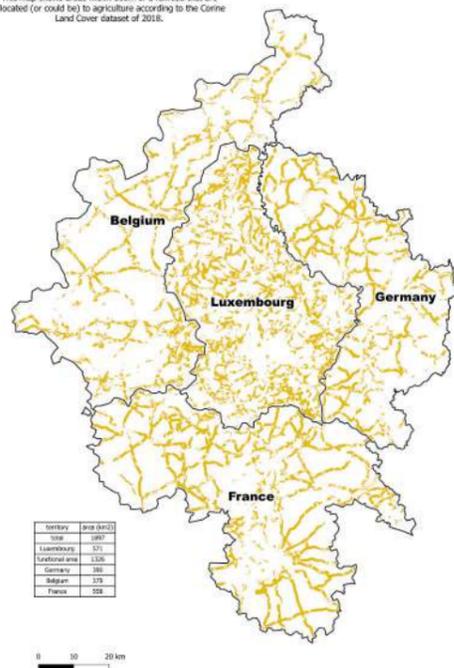
Polyculture opportunity
Total suitable area: 2894 km²

This map shows areas possibly used for polyculture agriculture according to the Corine Land Cover dataset of 2018. Land cover classes: 'Complex cultivation patterns', 'Non-irrigated arable land' and 'Land partially occupied by agriculture' are considered



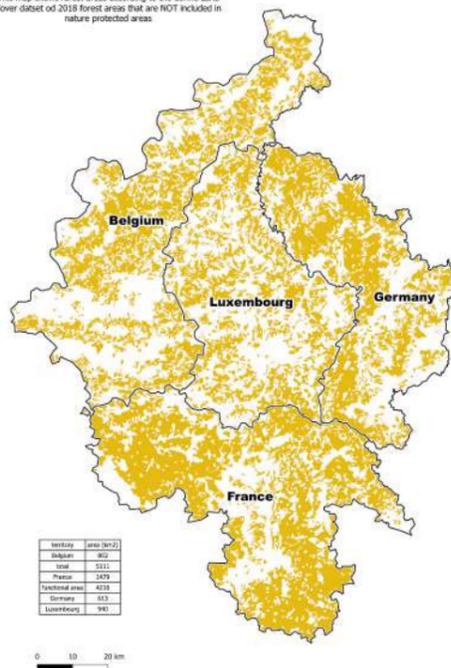
Production around railways
Total suitable area: 1326 km²

This map shows areas within 500m of a railroad that are allocated (or could be) to agriculture according to the Corine Land Cover dataset of 2018.

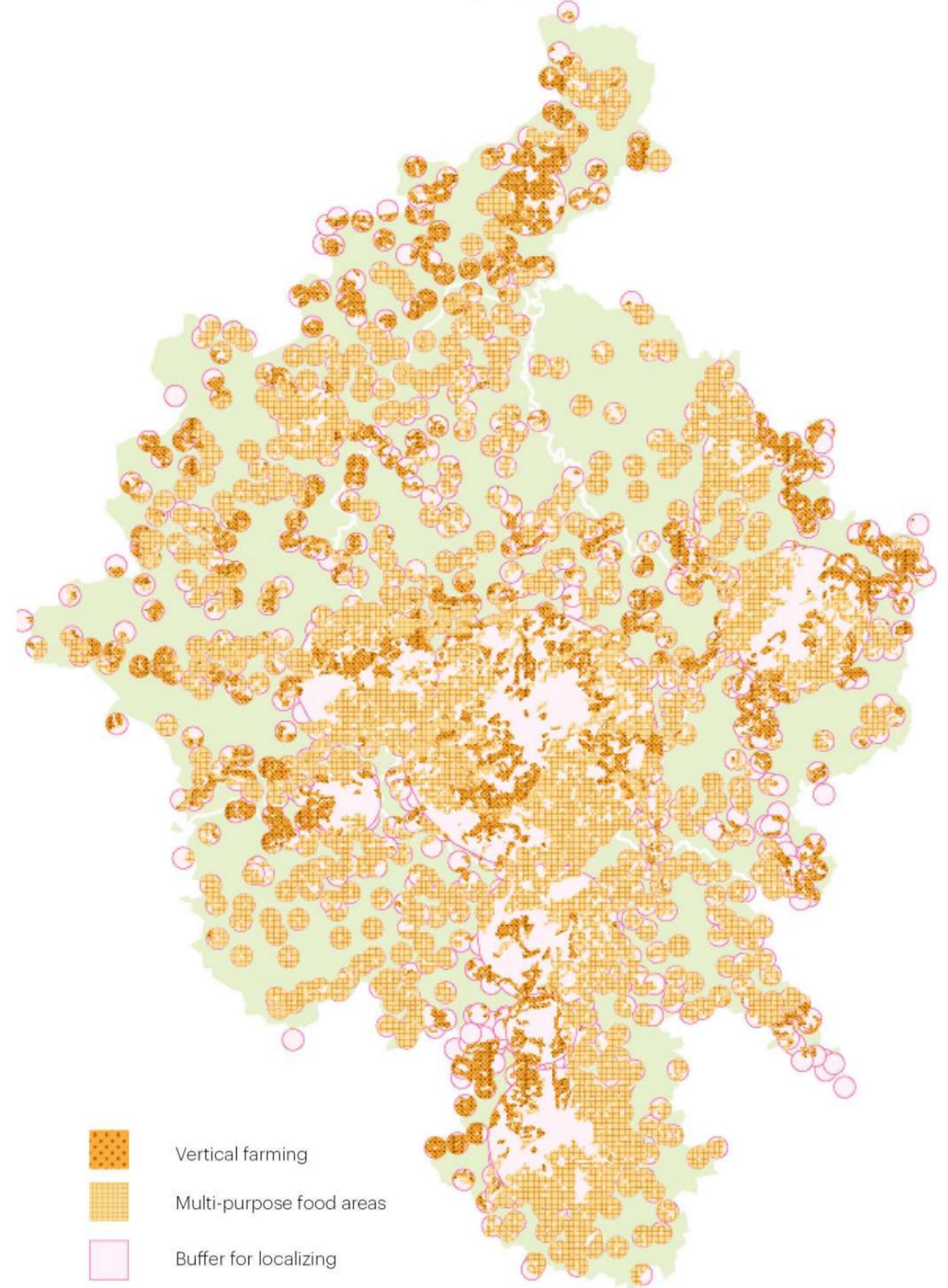


Productive forest areas
Total suitable area: 4216 km²

This map shows forest areas according to the Corine Land Cover dataset of 2018. Forest areas that are NOT included in nature protected areas



Food map by 2050



Food system by 2050

A large portion of the food I eat is produced in my own food belt around Frassem. There are services like weekly menus or meals prepared by local chefs and their pupils. The regional exchange between food belts ensures a large variety of ingredients which are all seasonal, and most of

them plant based. Meat and exotic products are still available for the age groups that need them, and for special occasions.

-25%

Food trade reduction



-0,87 MT CO2e

from cutting imports
vegetables & oil seeds

minimum import

maximum biodiversity

-1,09MT CO2e

carbon capture
new forest

85%

local production

8588 km2 production
from urban
green belts

7760 km2 production
from vertical farming

-1,49MT CO2e

85%

transformation
to organic farming

+85%

transforming pastures
& arable land into nature

-0,01 MT CO2e

+40%

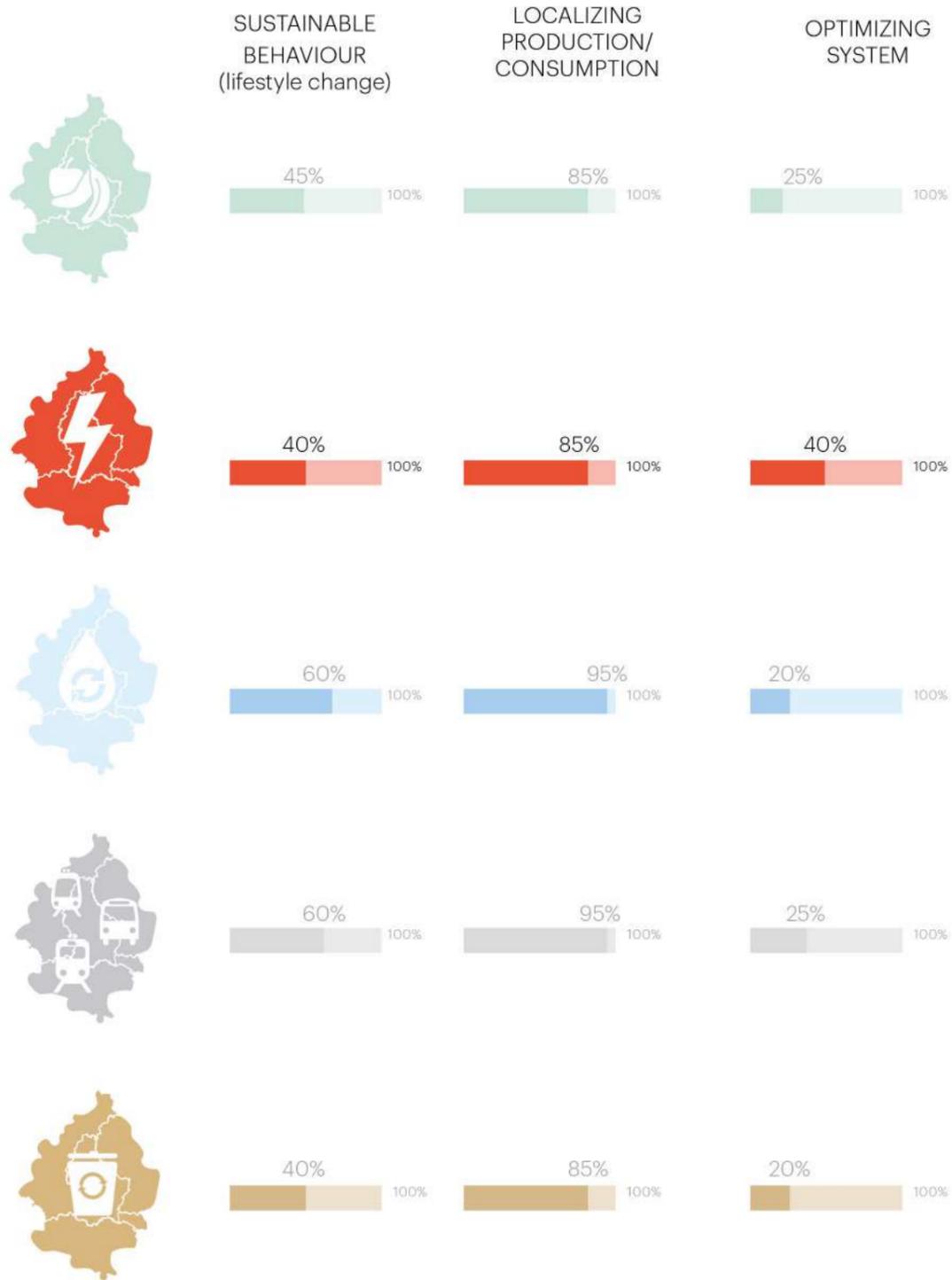
healthy and
plant-based diet

minimum
water for agriculture use

Healthy
water

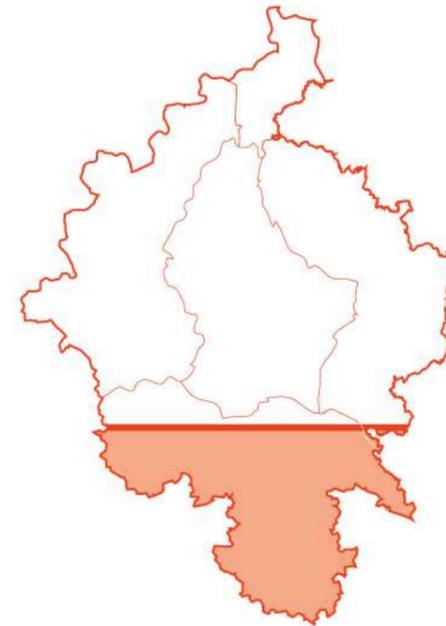
nature increase

Energy



Demand
3755km²

Proposed
4964km²



139km²

Solar

110km²

Solar + Wind

1663km²

3617km²

Wind

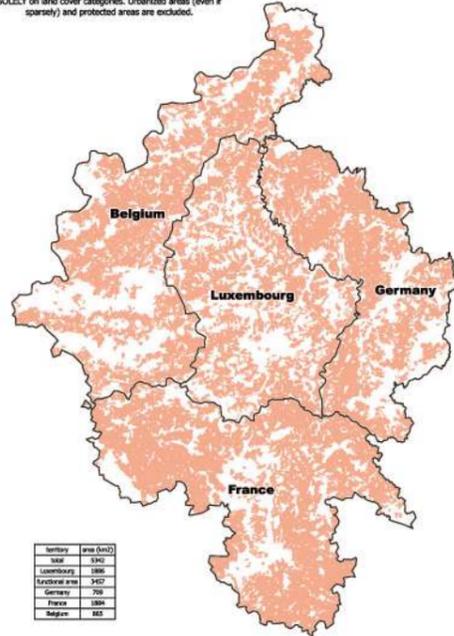
3191km²

Suitability areas

Windmill areas

Total suitable area: 3457 km²

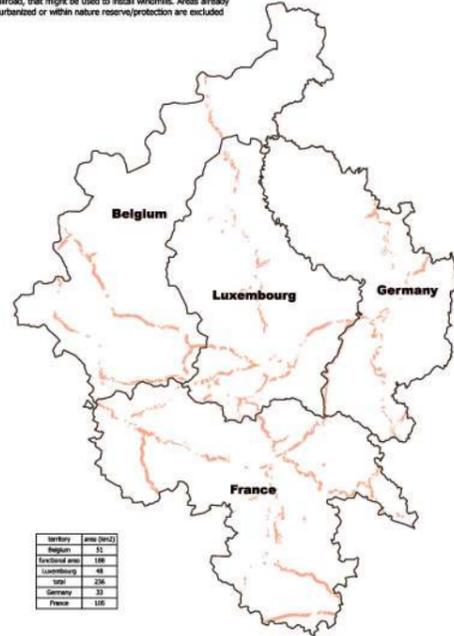
This map shows areas suitable for installing windmills based SOLELY on land cover categories. Urbanized areas (even if sparsely) and protected areas are excluded.



Windmill along railways

Total suitable area: 188 km²

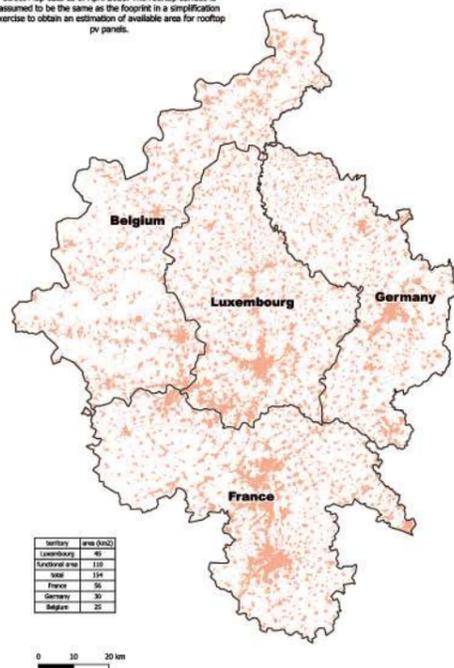
This map shows areas within 400m from each side of a railroad, that might be used to install windmills. Areas already urbanized or within nature reserve/protection are excluded



PV on buildings

Total suitable area: 1110 km²

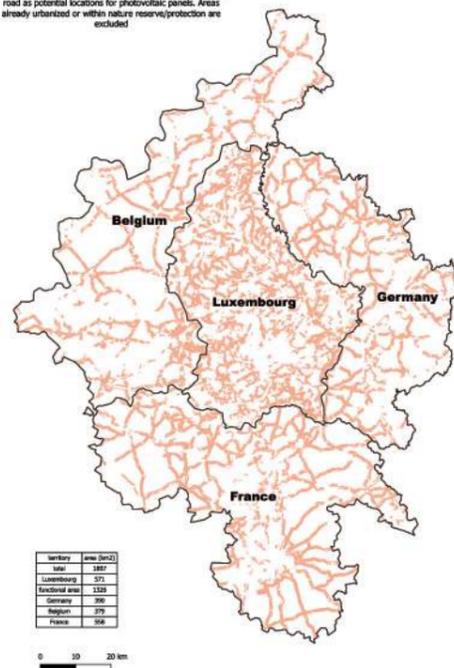
This map shows the footprint of buildings according to Open Street Map data as of April 2021. The rooftop surface is assumed to be the same as the footprint in a simplification exercise to obtain an estimation of available area for rooftop PV panels.



PV along infrastructure

Total suitable area: 1346 km²

This map shows areas within 400m from each side of a main road as potential locations for photovoltaic panels. Areas already urbanized or within nature reserve/protection are excluded



Energy map by 2050



-  PV on buildings
-  Stacking windmills
-  Windmill areas + PV areas + other function
-  Buffer for localizing

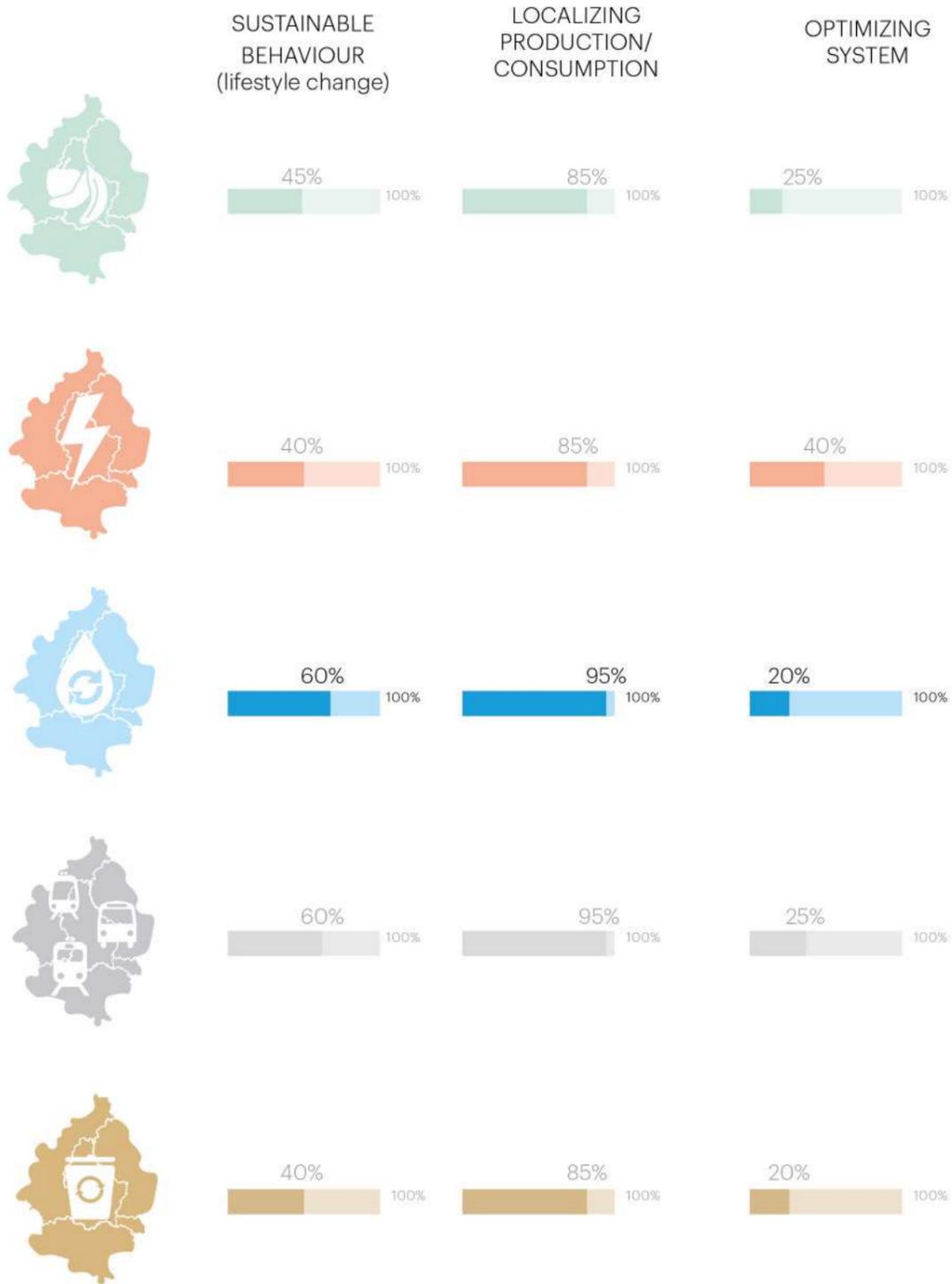
Energy system by 2050

In this shift, my household's energy consumption decreased and now we produce more than we consume. The excess energy of the neighbourhood is used in the local greenhouse and in a Arlon factory that makes new electric bikes and

scooters by up-cycling fossil-fuel based ones. Energy from the wind parks in the north of the bioregion are distributed to larger industrial activities and to cities who cannot produce enough themselves.



Water

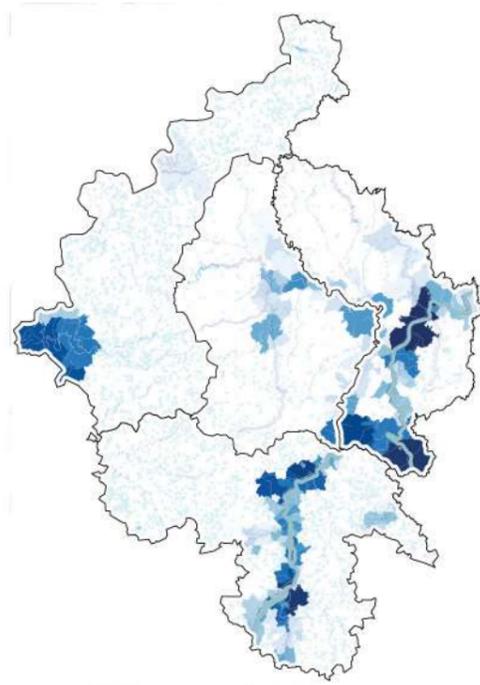
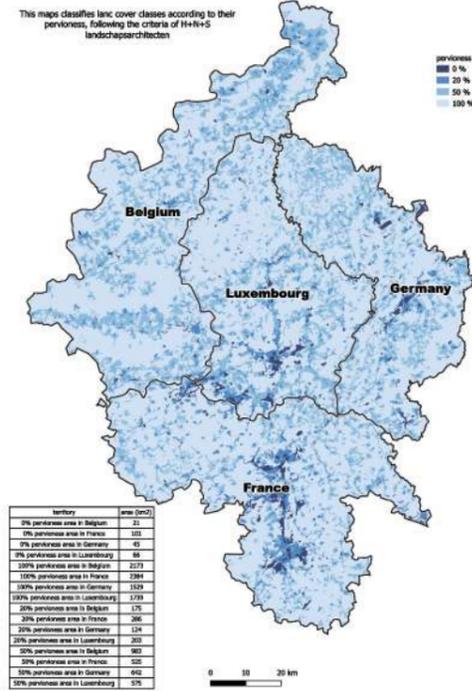


Suitability areas

Water map by 2050

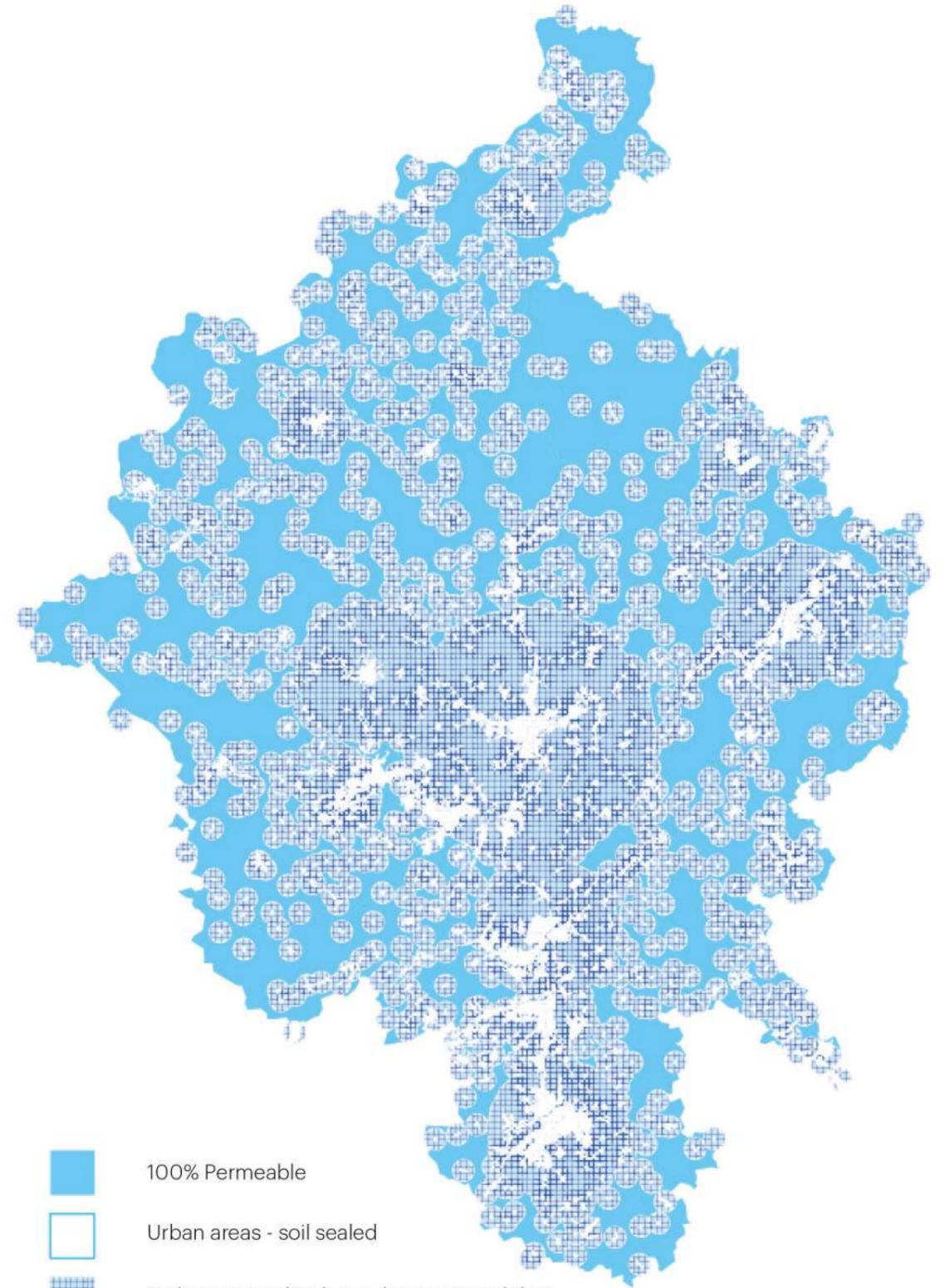
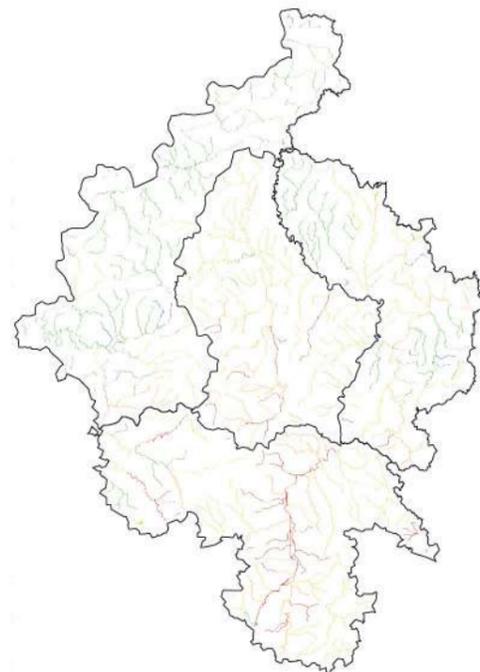
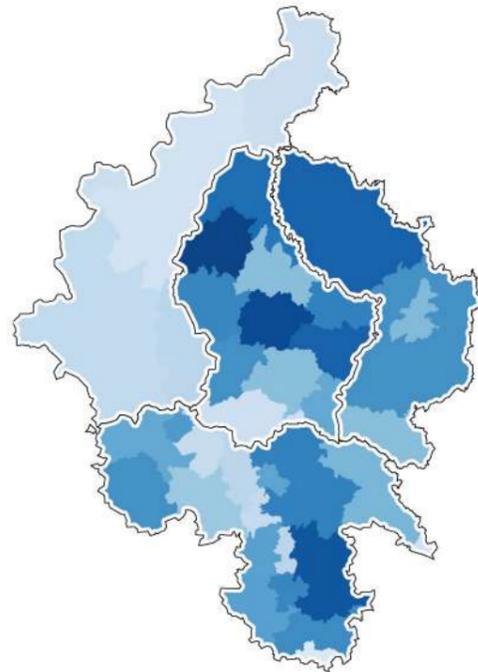
Pervioness level
Areas from 0% to 100%

Flood risk Areas
Areas with high flood risk



Soil sealing change
Areas with increasing soil sealing

Impaired bodies of water
Areas with low quality on surface bodies of water

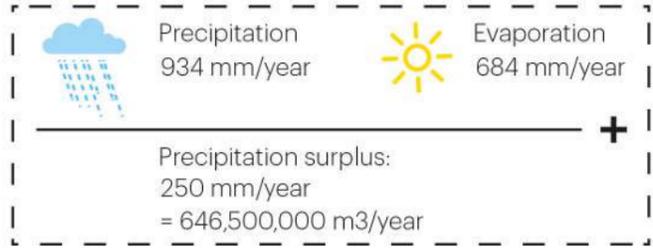


- 100% Permeable
- Urban areas - soil sealed
- Multi-purpose land - medium permeability
- Buffer for localizing

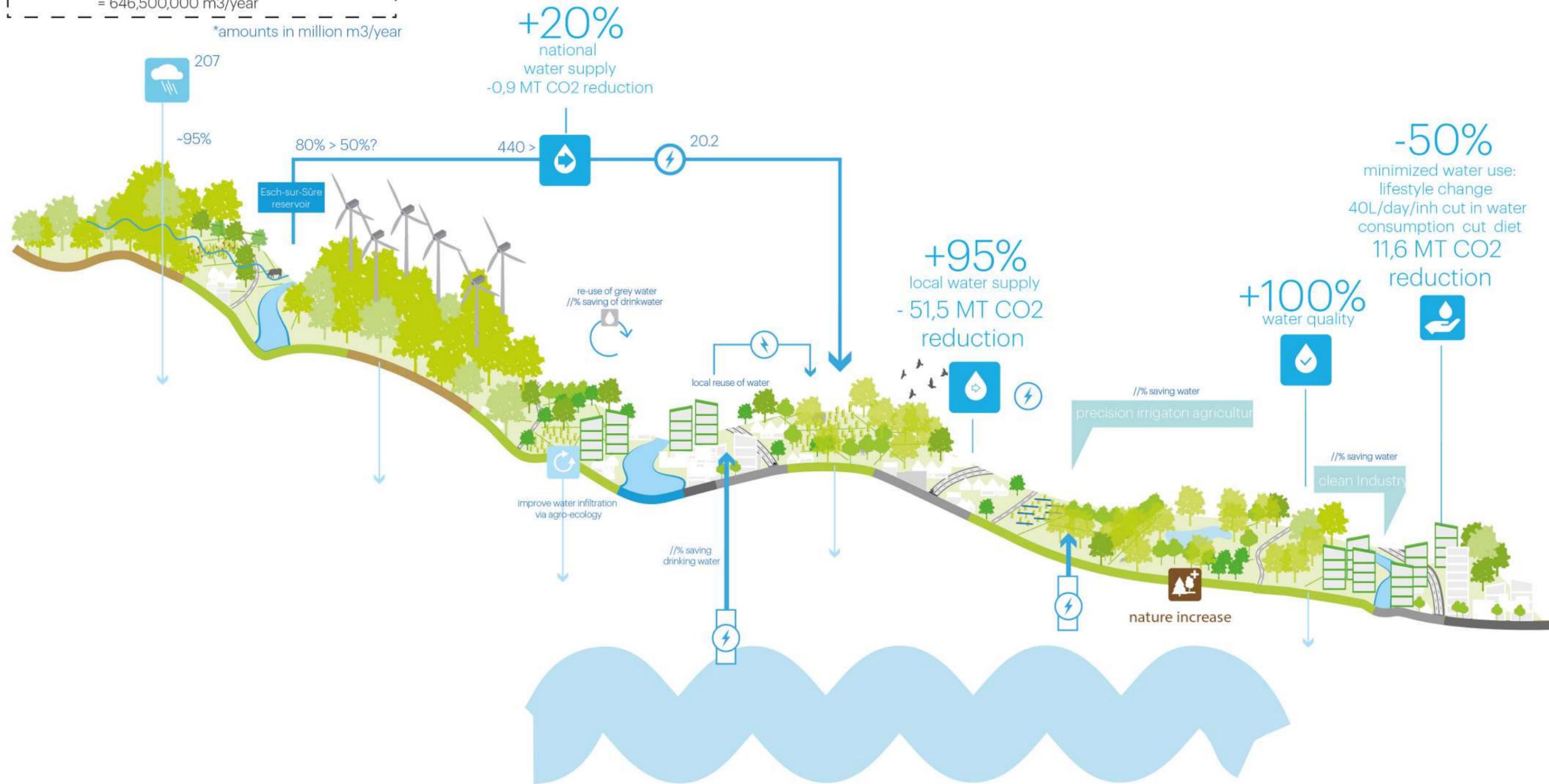
Water system by 2050

It's hard to imagine that we once had so many polluted water ways. Water purification has become the standard in all household technology and industrial plants. Agricultural activities no longer create pollution. This makes the local reuse

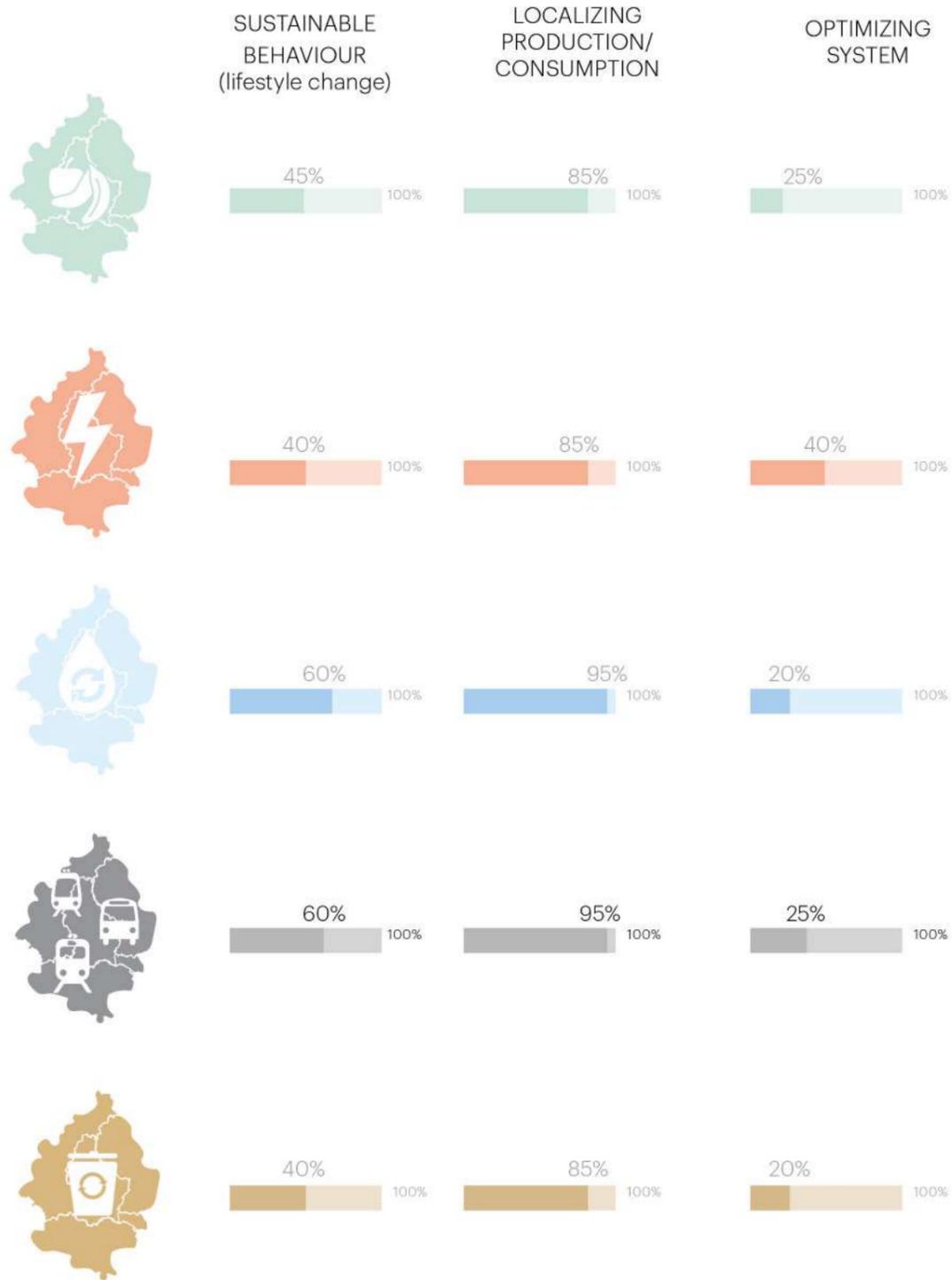
of water for potable purposes easy for everyone. The large water basins in Esch-sur-Sûre are only needed for agriculture and during droughts.



*amounts in million m³/year



Mobility



Demand
324km²

Proposed
324km²

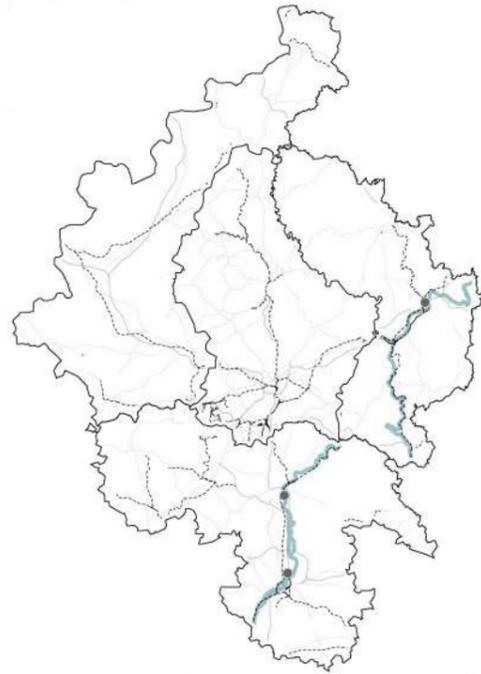


Lifestyle	207 km ²
Optimize	6 km ²
Localize	111 km ²

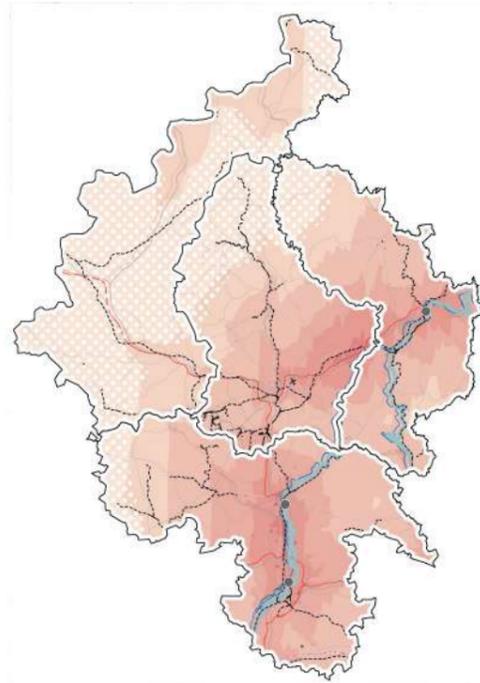
Suitability areas

Energy map by 2050

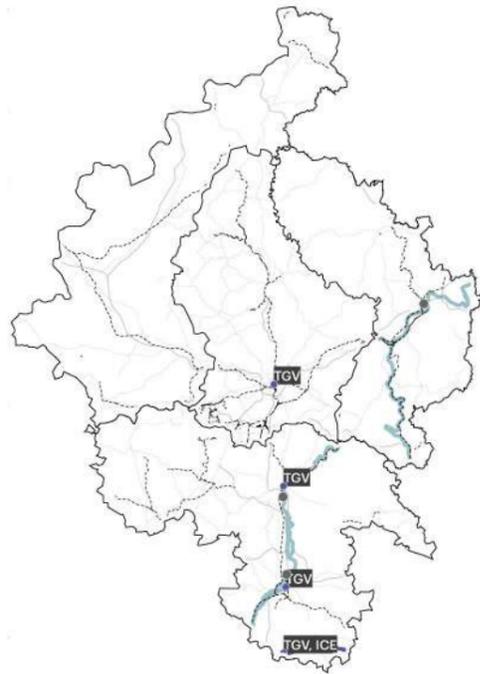
Trimodal Hubs
Areas with high connectivity



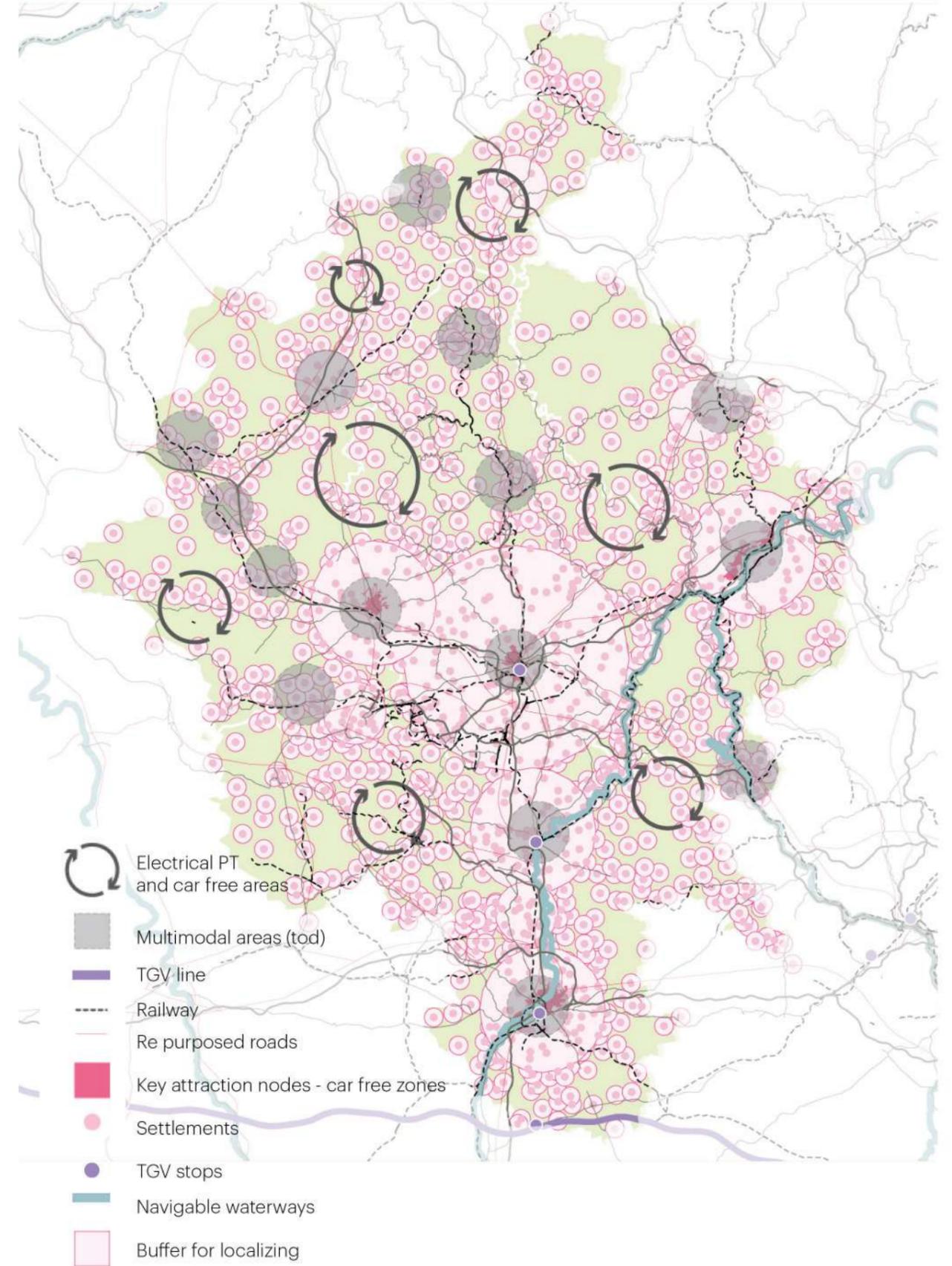
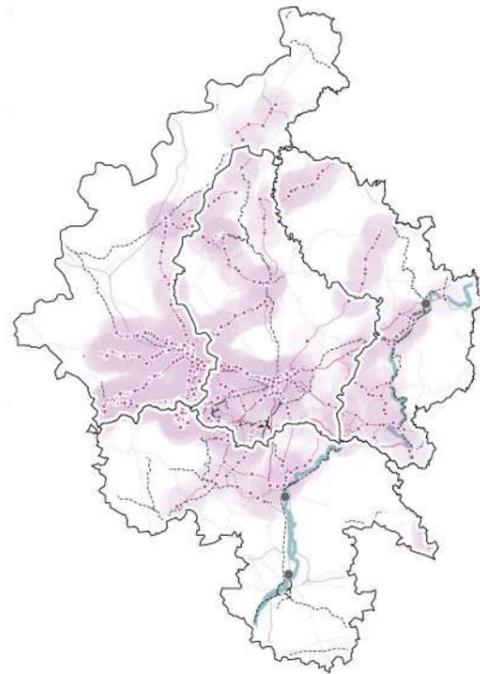
Freight - Unserved areas
Areas with low accessibility to the movement of goods



TGV stations
Areas with high international connectivity



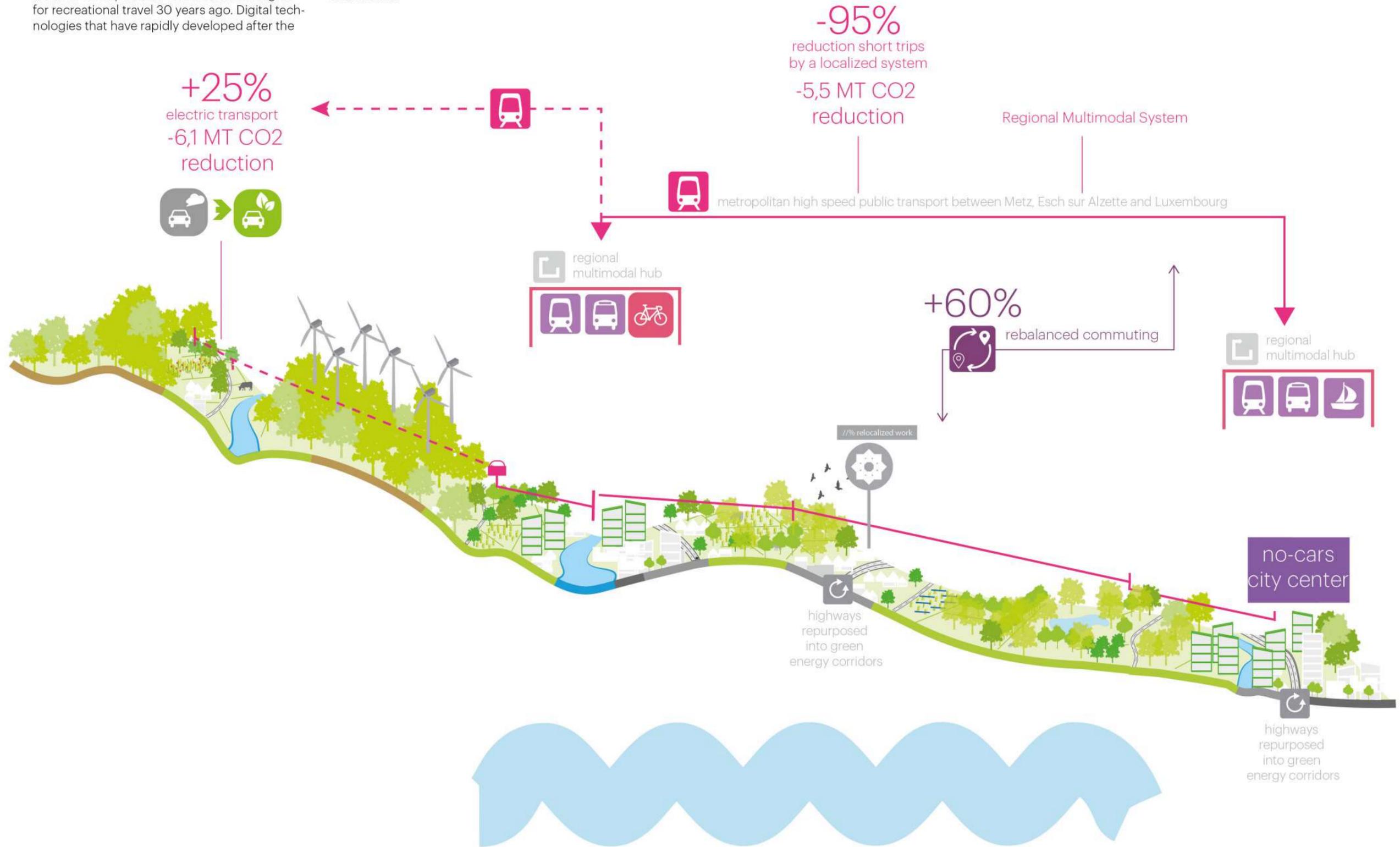
Cross-border bus lines and stations
Areas with high accessibility to PT



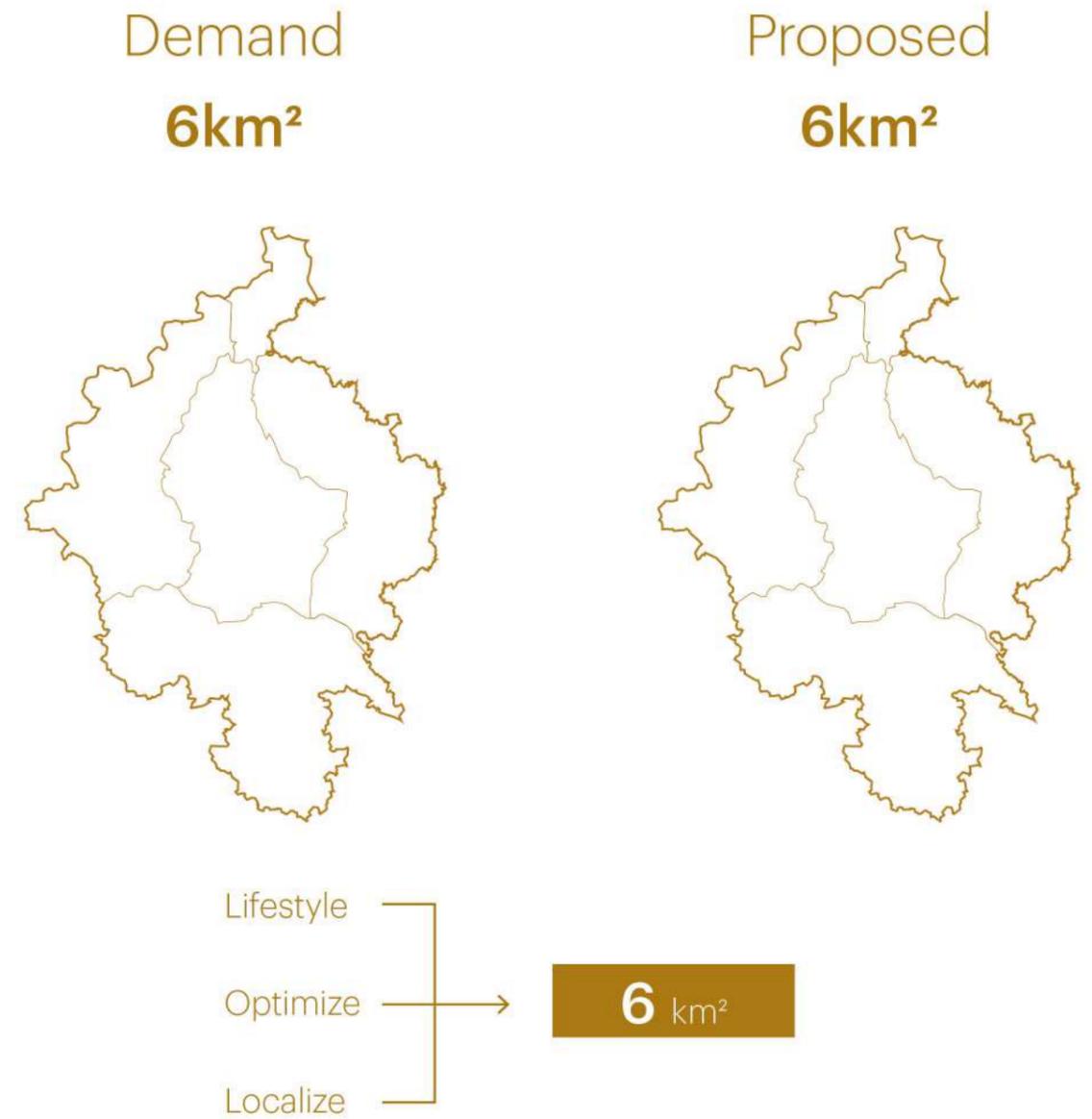
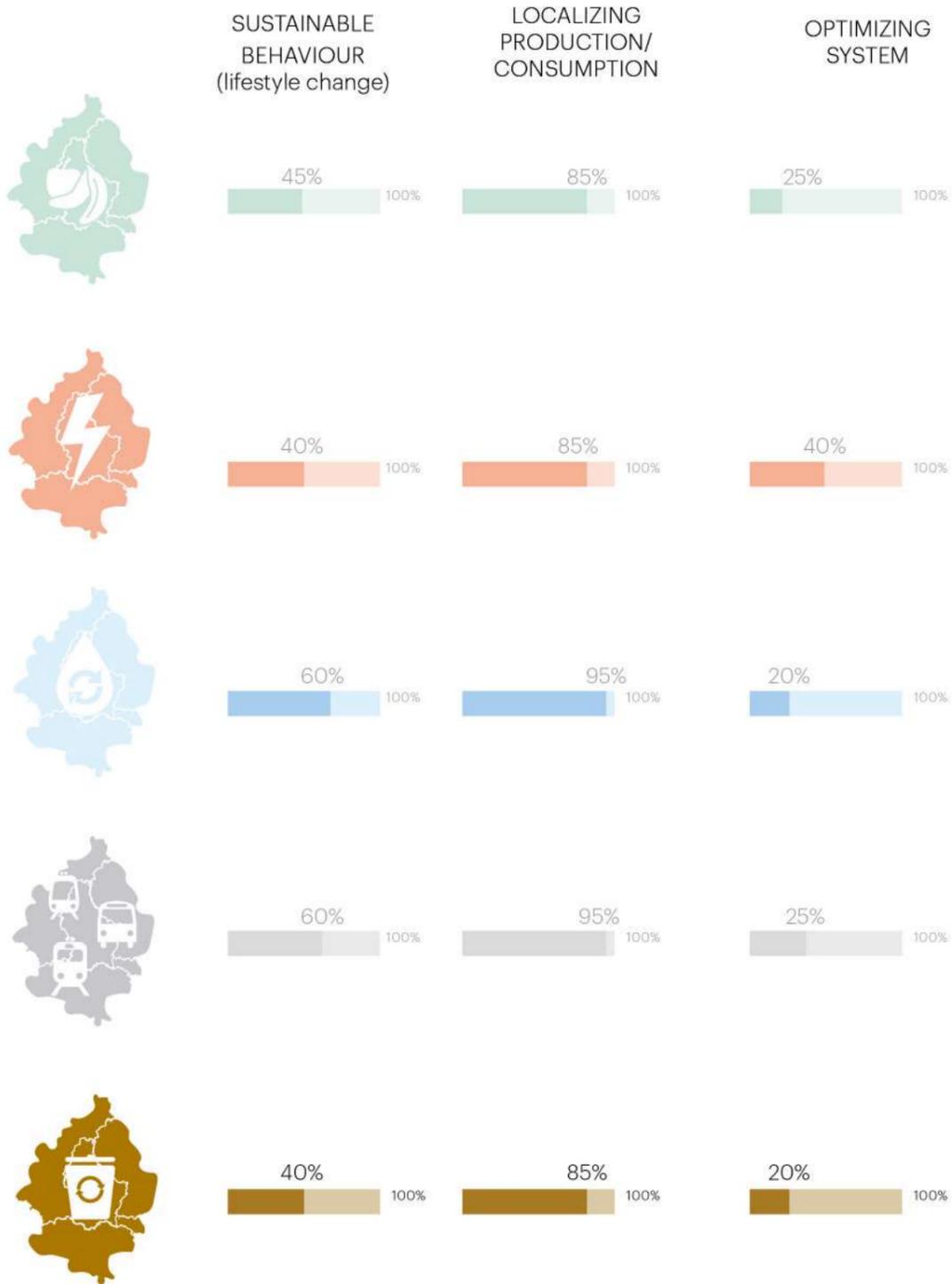
Mobility system by 2050

We live close to where my wife and I work. The local environment is amazing for recreation and for recharging. We often spend time in the North area for holidays. It's hard to imagine that we were so dependent on international flights for recreational travel 30 years ago. Digital technologies that have rapidly developed after the

COVID crisis have replaced business travel. My kids are so used to biking to school, that when I tell them in my time this wasn't possible because cars dominated the streets, they simply don't understand.



Waste



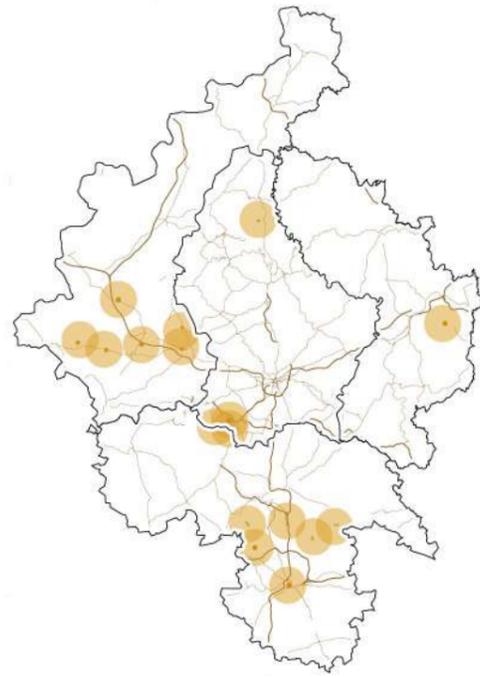
Suitability areas

Dump sites
area: 5,4 km²

This map shows existing dump site areas according to the Corine Land Cover 2018 dataset.

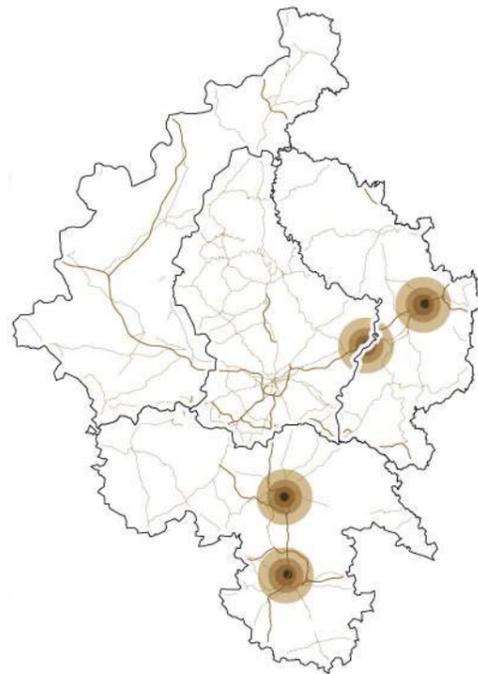


Recycling centres
waste management sites

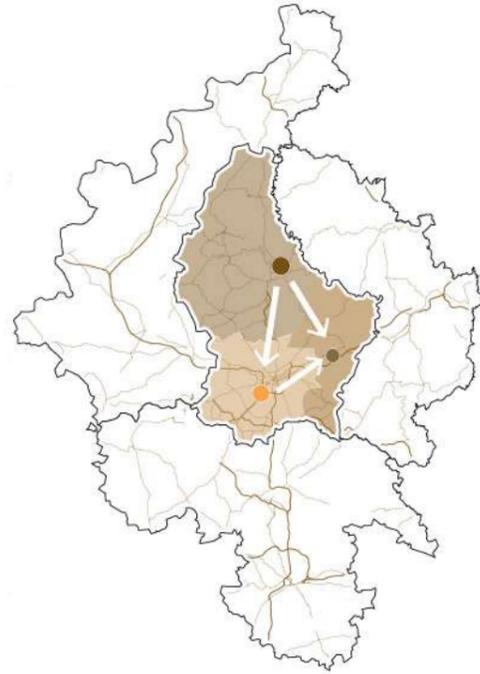


Trimodal hubs

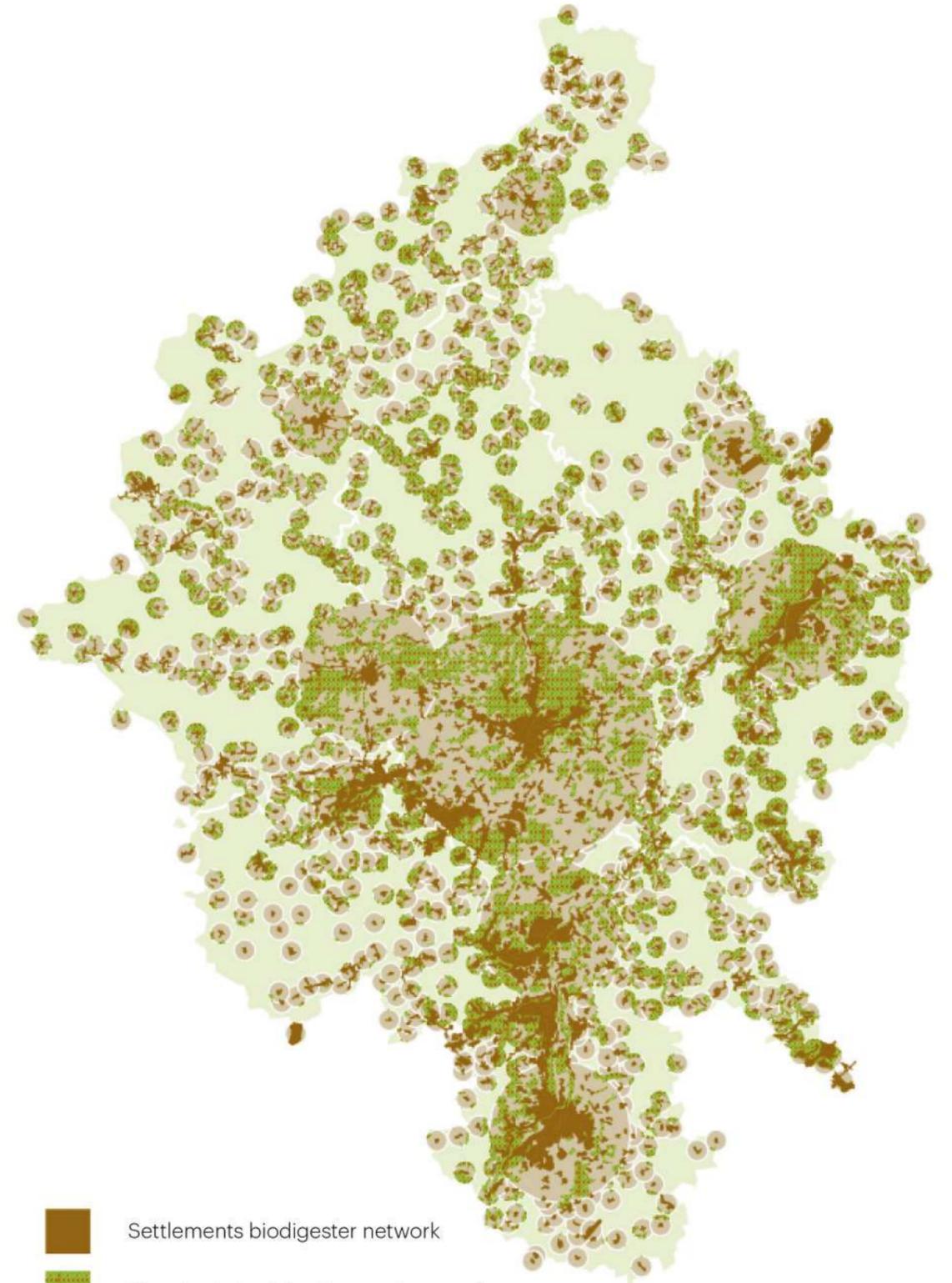
Potential location for wood hubs or circularity hubs



Existing waste management districts
SIDOR, SIDER, SIGRE sites



Energy map by 2050



- Settlements biodigester network
- Wooden-hubs (circular wood system)
- Buffer for localizing waste processing

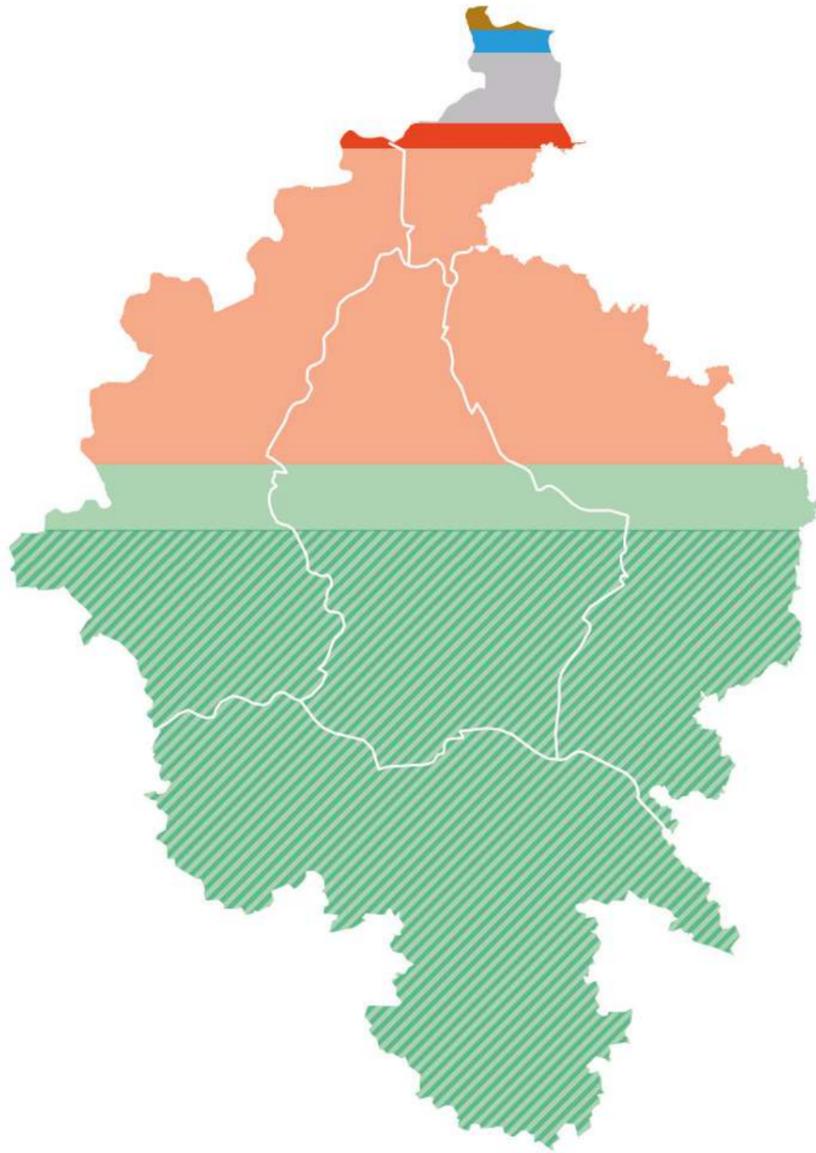
Waste system by 2050

The concept of waste that we work with today is "the longer you own something, the better." In fact, the taste for virgin materials has rapidly declined. The little waste that we still have we transform into a resource. We have also heavily invested in repair and re-purposing awareness and skills.

For example, in Trier the open university offers training programmes in up-cycling skills for every sector, so students and professionals develop skills which make the system more robust and in constant innovation and development.

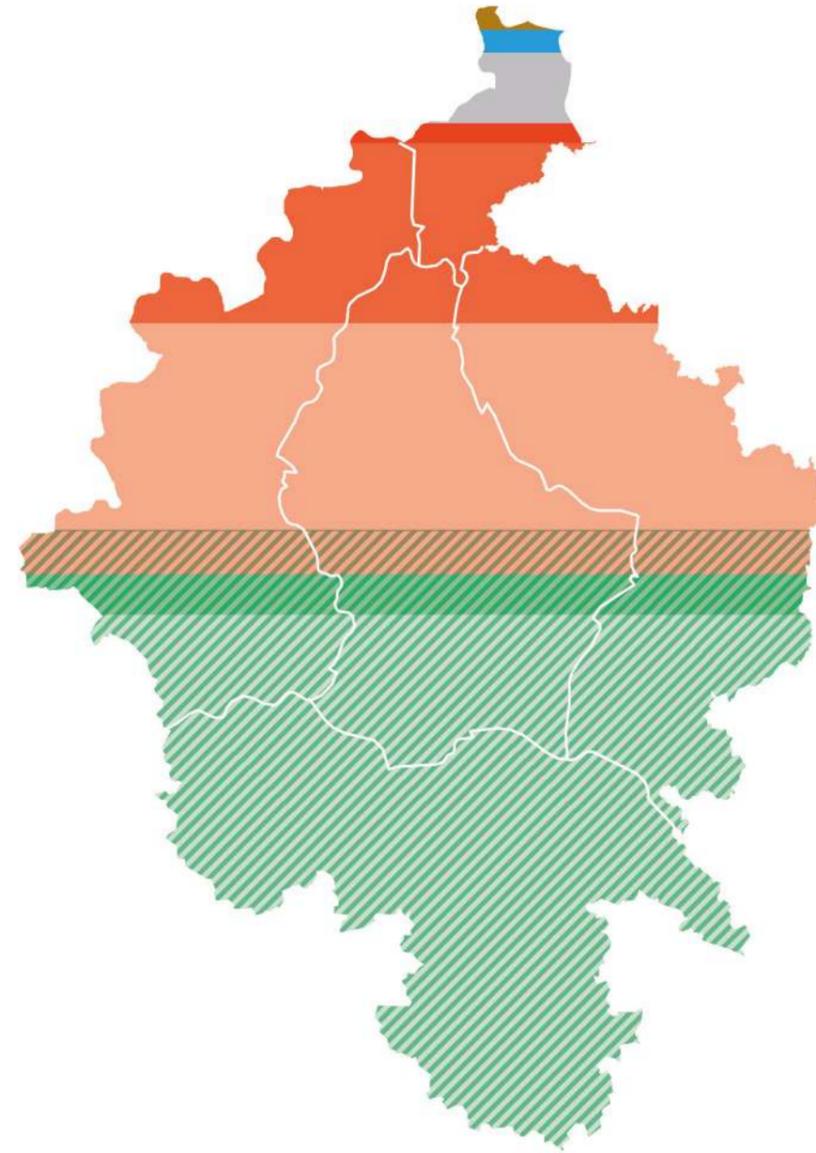


Demand

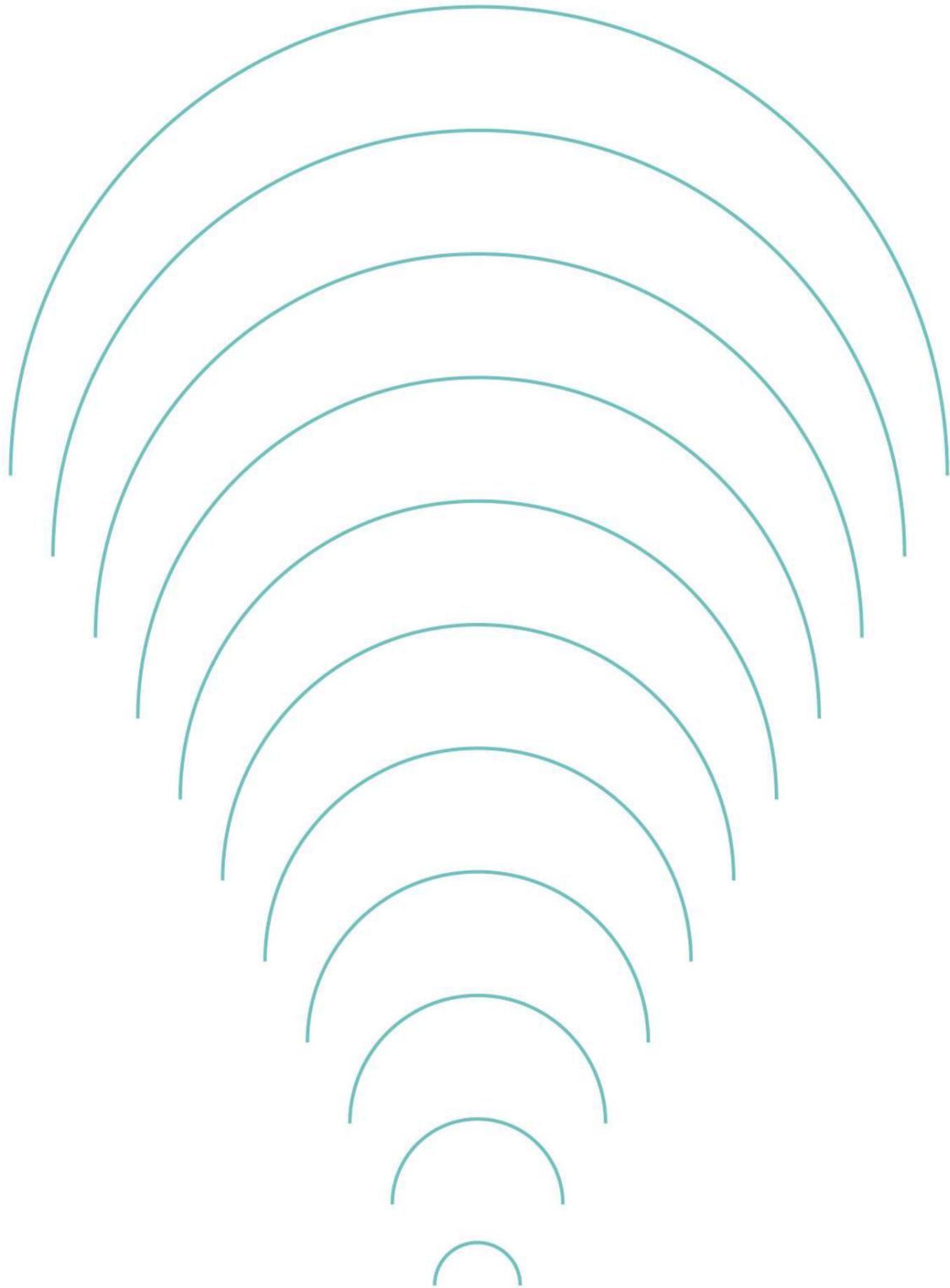


Waste	6 km ²
Water	57 km ²
Mobility	324 km ²
Solar	139 km ²
Wind	3617 km ²
Food	15865 km ²

Proposed



Waste	6 km ²
Water	57 km ²
Mobility	324 km ²
Solar	110 km ²
Solar + Wind	1663 km ²
Wind	3191 km ²
Vertical Farming	7760 km ²
Multi-purpose	8588 km ²



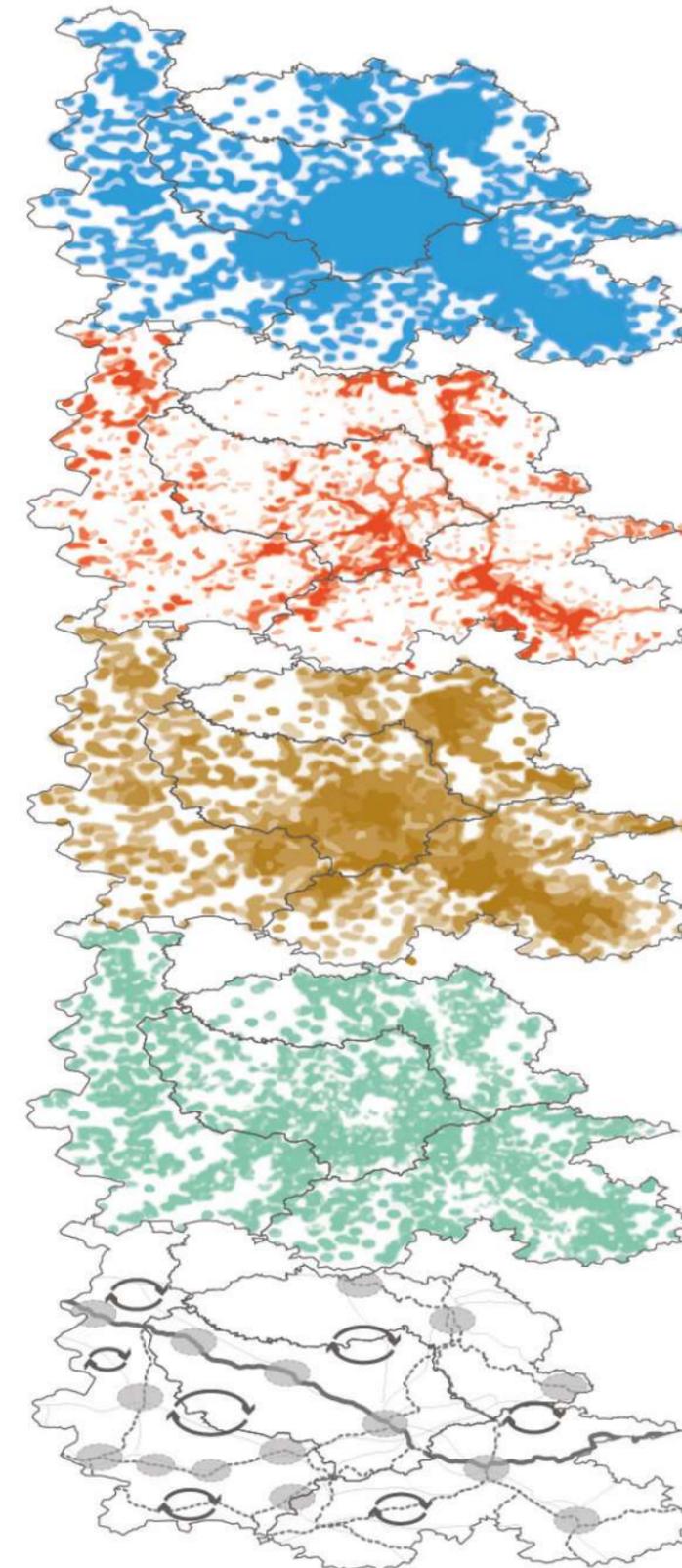
A multilayer
proposal

The vision: multi-purpose of land

With multiple functions like food, energy, water, mobility and waste interacting and all claiming vast amounts of space, spatial planning that simply arranges these functions side by side is no longer sufficient. Spatial planning should instead focus on the integration of these functions to determine how they come together to make the best use of a certain territory. Actually, spatial planning should employ a bottom-up approach: how can a certain territory provide for food, energy, and all needs in the most efficient, sustainable and attractive way? In fact, it's time to reconsider the legend of our topographic maps. Instead of items like 'forest' or 'agricultural land' these should say 'agroforest' and 'wind field'.

Just as an example, an agroforest would present a spatial synergy between ecological values, recreation, and timber production. Following the established concept of nature-based forest management, extensive, and ecologically-informed tree harvesting will not only provide the building industry with high quality locally grown wood, but also enhance biodiversity, and thereby recreational values. Over time, this will transform Luxembourg's monotonous production forests

into profitable sanctuaries that allow precipitation to optimally replenish ground water. In wind fields, intensive, and large-scale agricultural land does not only provide efficient food production. It also accommodates electricity generation through XXL wind turbines. Both functions require industrial scale and infrastructure. The revenues from energy production will also transform farmers' dependency on subsidies into a self-confident and investment attracting business.



Water

+

Energy

+

Waste

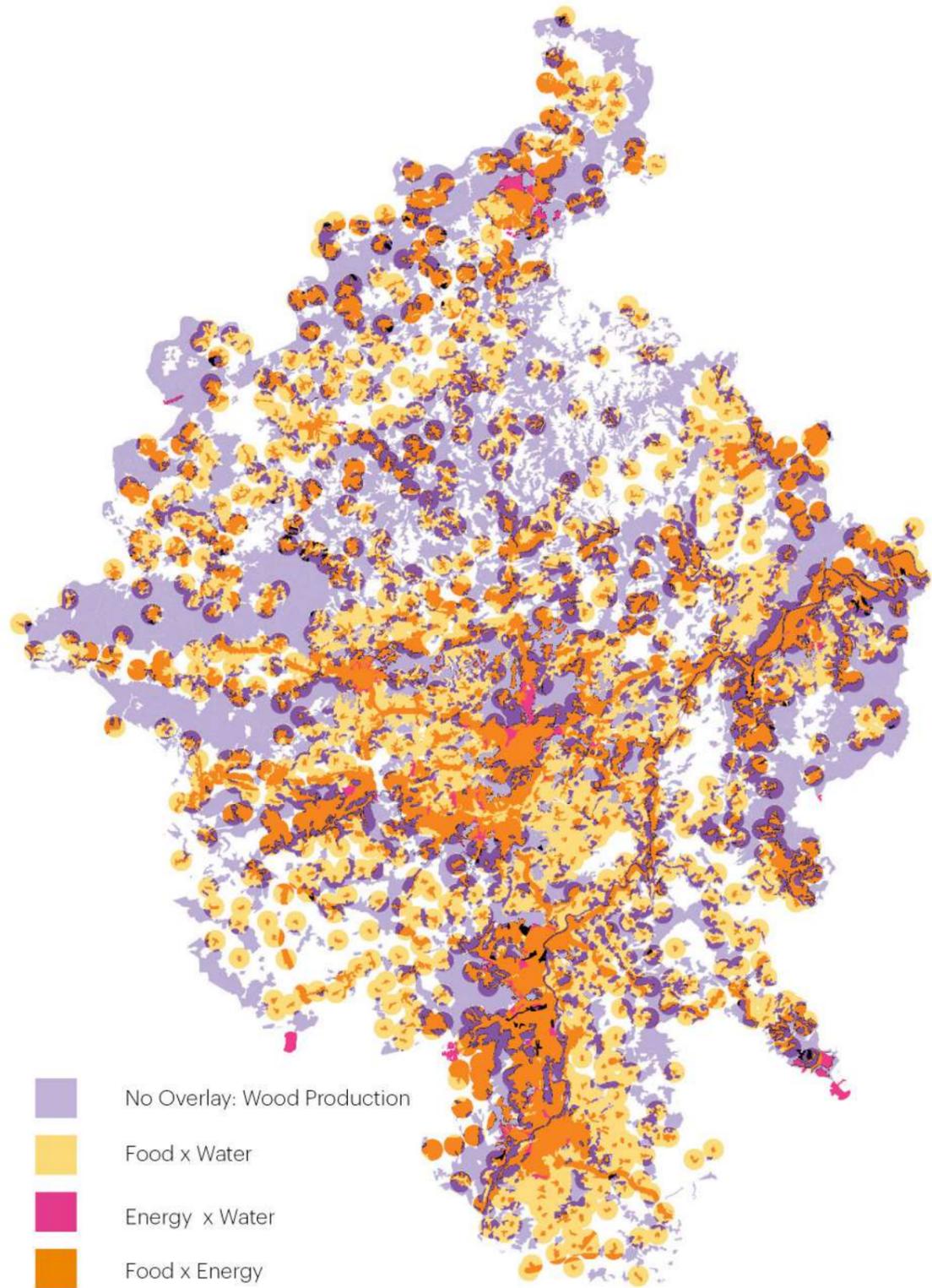
+

Food

+

Mobility

Finding the synergies

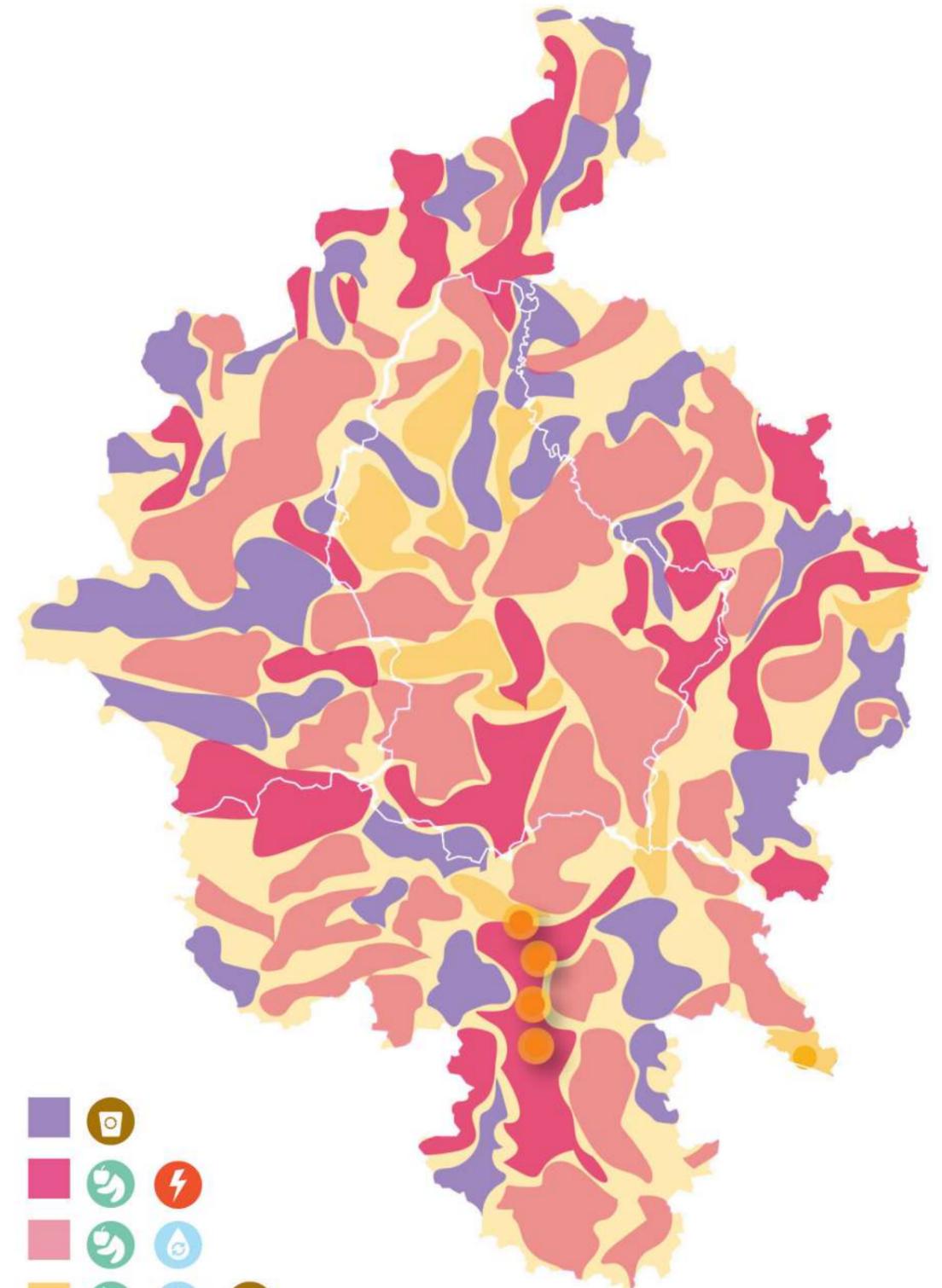


Ecotopia scenario

260

Beyond lux(e) - Stage 02

Clustering the synergies



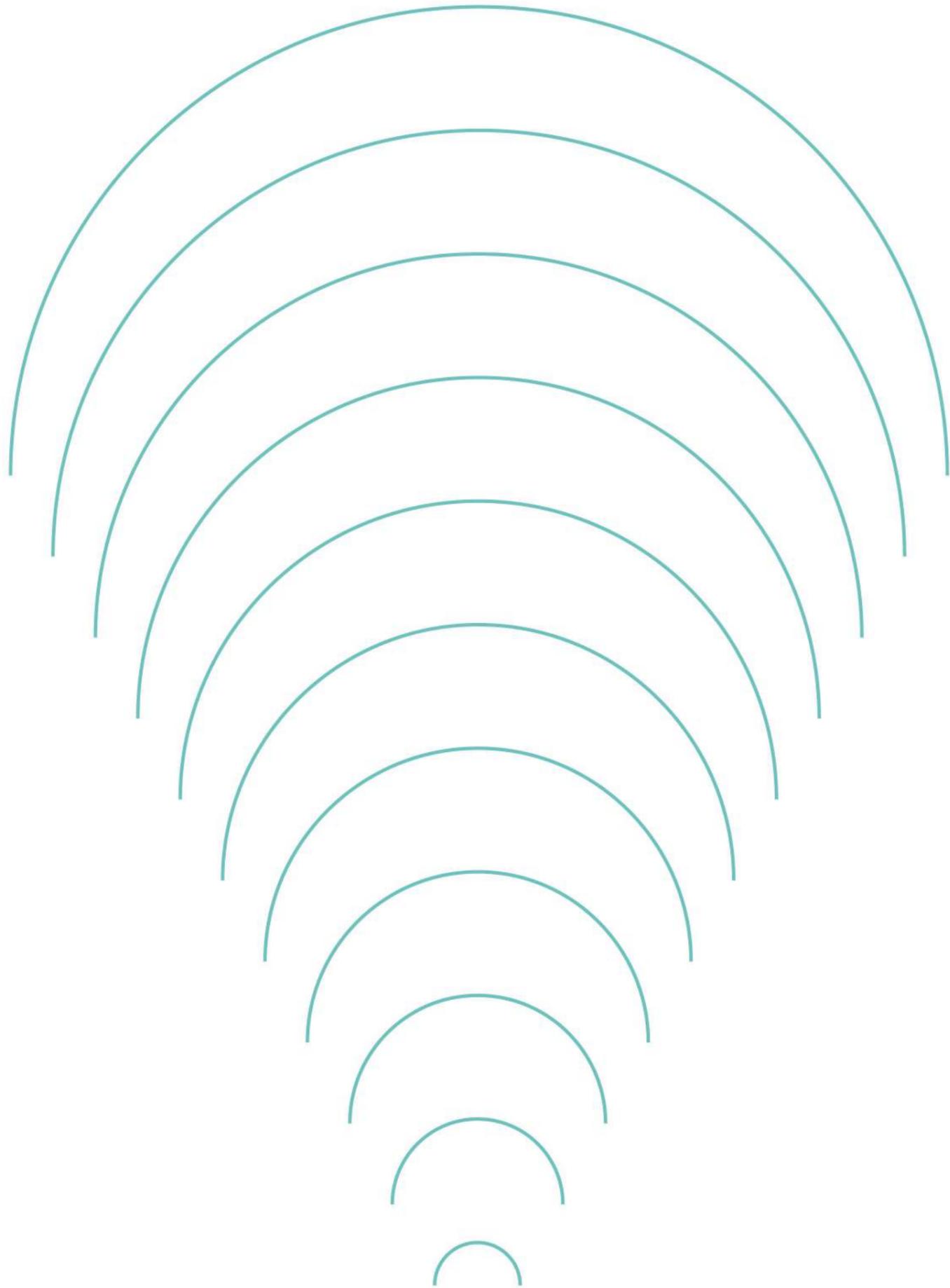
Ecotopia scenario

261

Beyond lux(e) - Stage 02

A collective network of villages





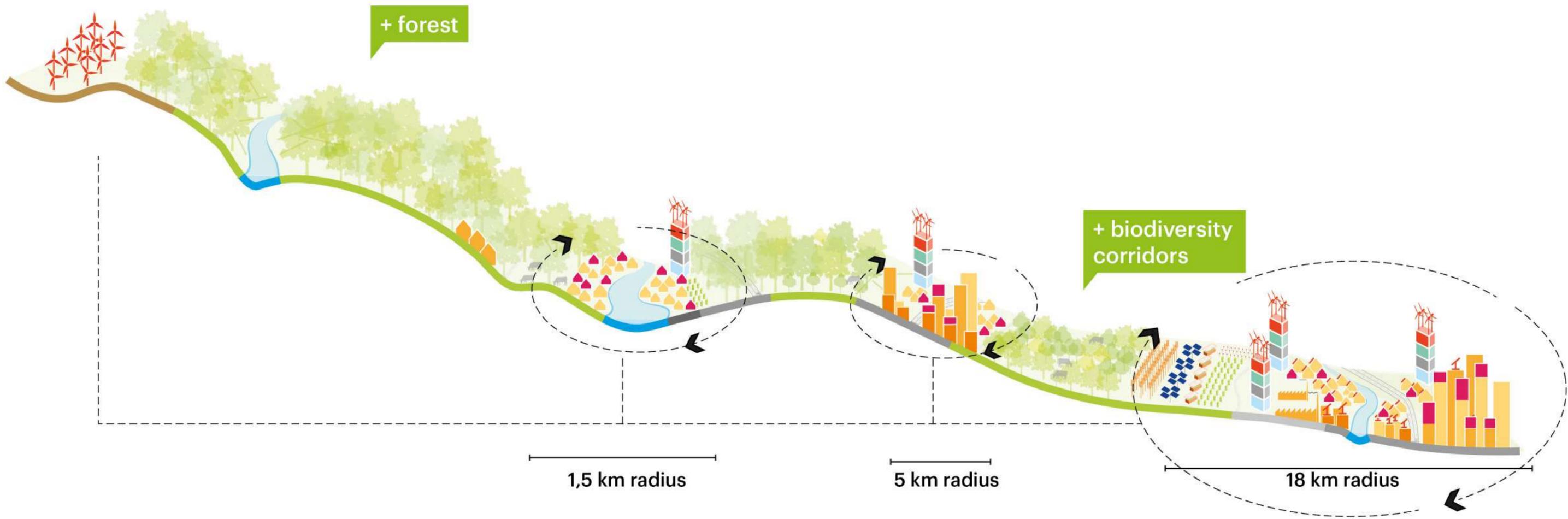
The benefits

More permeable, more natural

In Luxembourg's semi-continental climate with its mild winters and cool summers, and its naturally fertile soils, we are blessed with an abundance of water and nutrients that provide for lush vegetation and high crop yields. But both water and water and nutrients show a considerable spatial and temporal variation that must be dealt with. Here nature is our greatest ally.

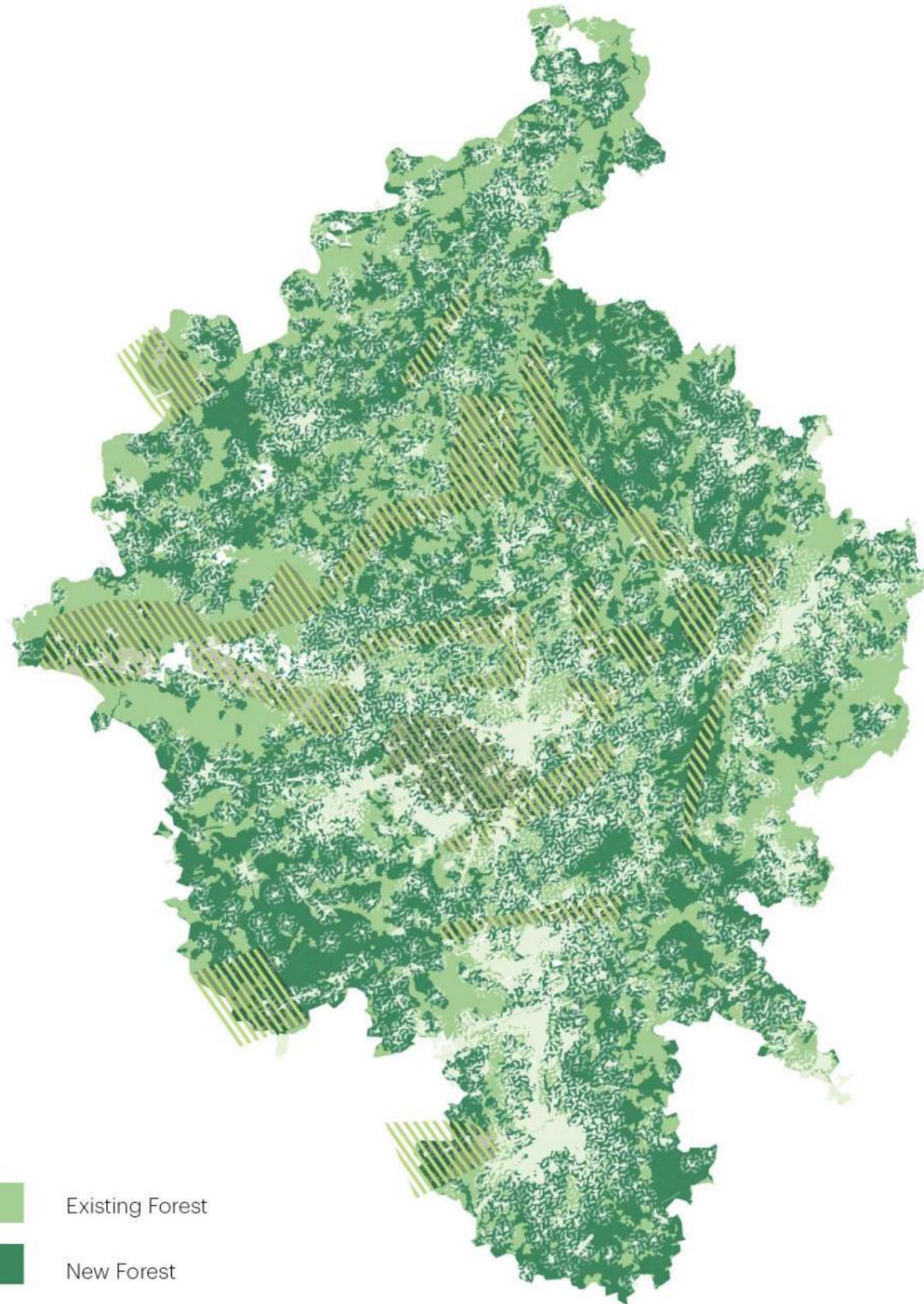
Our soils naturally have a great capacity to buffer water, nutrients and carbon, as long as we just allow it to do so. However, our current management of both agricultural and urban soils seriously hampers their buffering capacity. A more permeable soil, that allows interaction of processes above and beneath ground level, is therefore literally fundamental to a sustainable use of our landscape.

And that's exactly what Beyond LUX has achieved. Through decarbonization, balancing growth and integrating functional layers into a more sustainable landscape composition we have also increased Luxembourg's natural areas by ... km² and regained unimpeded natural cycles of water, nutrients and biomass. These cycles are of vital importance because they deliver ecosystem services to the economy and at the same time bend the climate and biodiversity crises in a positive direction.



Defining naturalized areas

More biodiversity, more ecology



- Existing Forest
- New Forest
- To Protect
- To Multi-purpose

- Existing Forest
- New Forest
- To Protect
- To Multi-purpose

Ecotopia scenario

268

Beyond lux(e) - Stage 02

Ecotopia scenario

269

Beyond lux(e) - Stage 02

Next steps

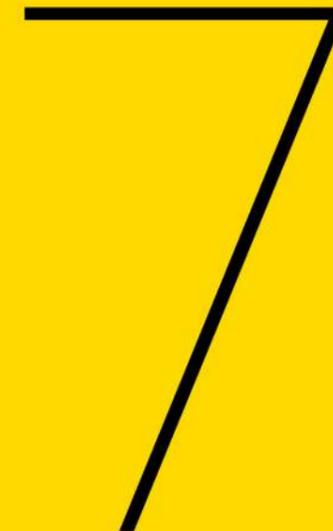
Three Strategic projects

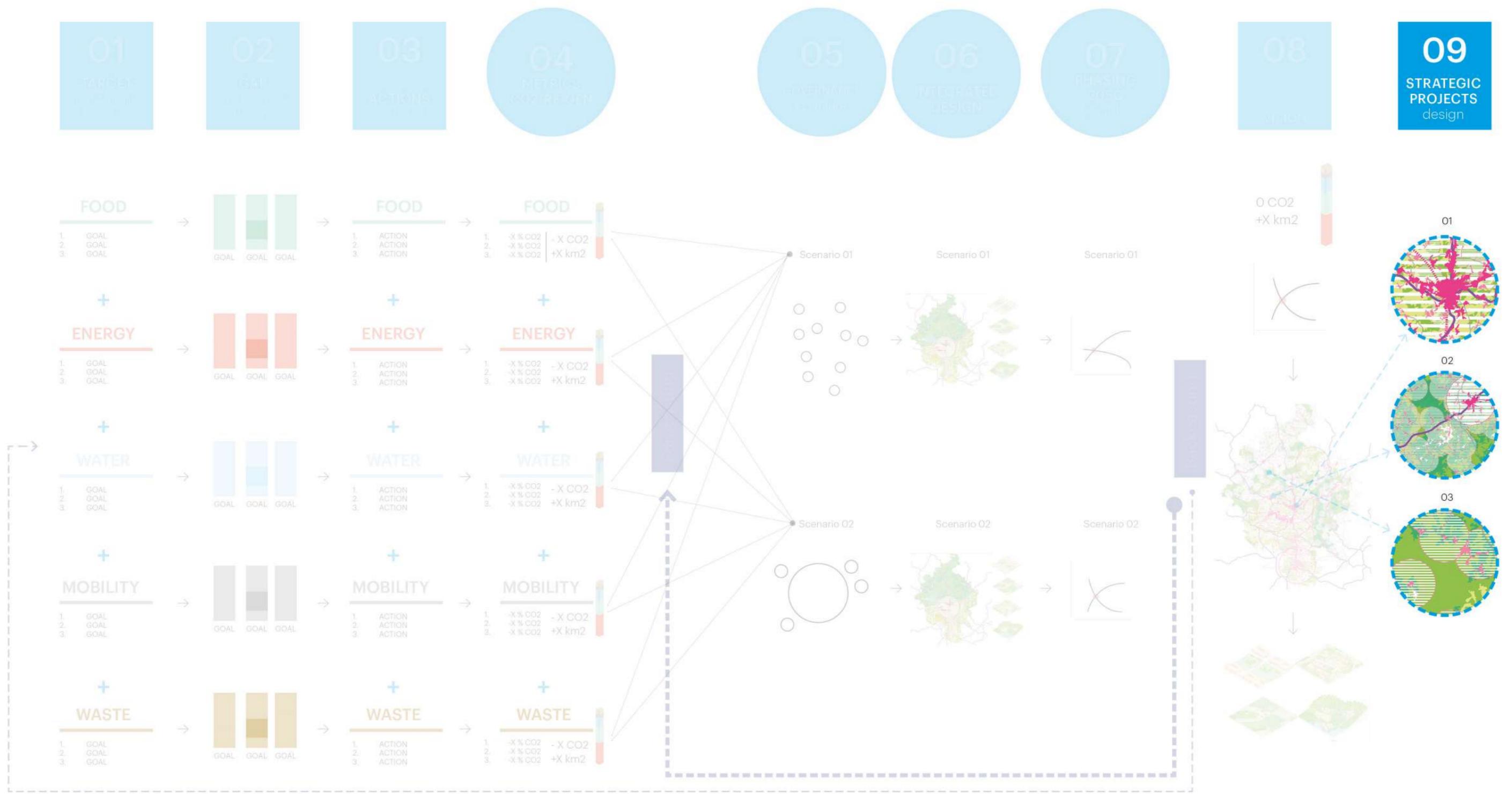
01 Balancing urbanity and nature

02 Clustering for self-sufficiency

03 Enhancing natural systems

Phase 3



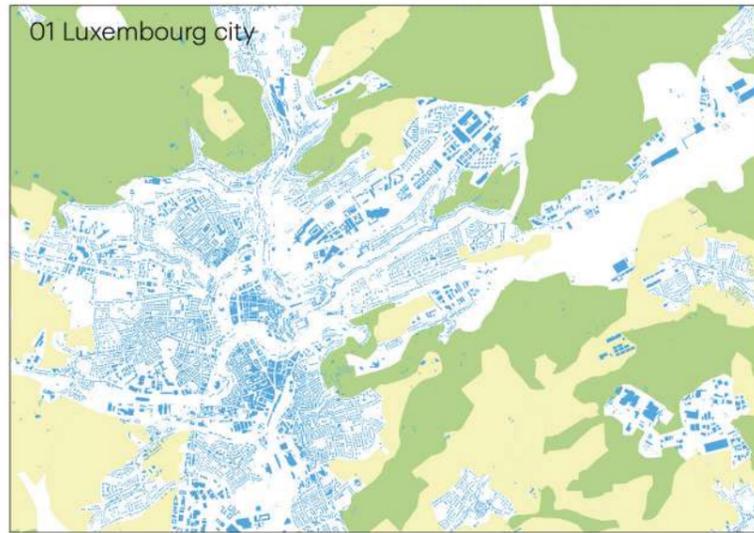




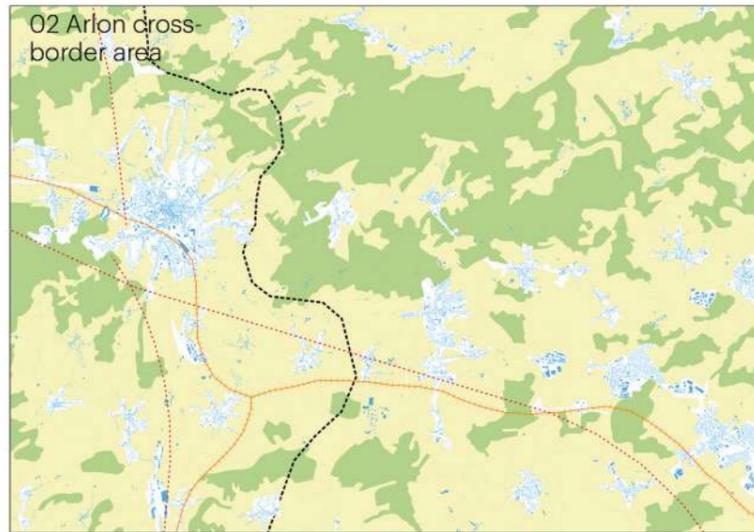
Three
strategic
projects

The three strategic projects

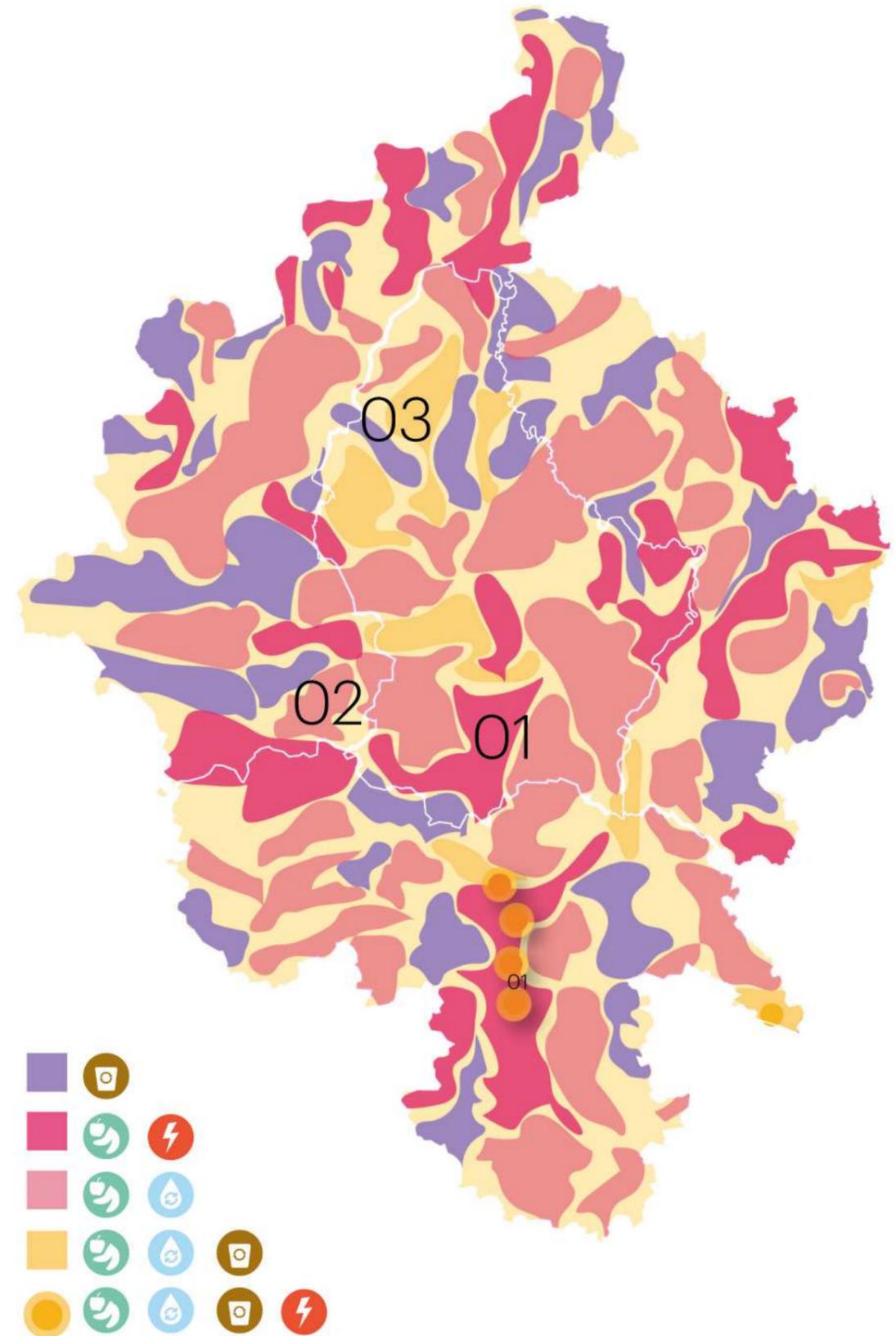
01
Balancing
urbanity
and nature



02
Clustering
for sel-suffi-
ciency



03
Enhancing
natural
systems





01 Balancing urban and nature



How to intensify existing urban fabric?

How to generate self-sufficient neighbourhoods?

How to contribute to intensification and enhance heritage values?

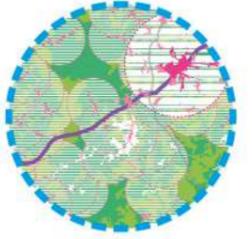
How to generate a productive green infrastructure?







02 Clustering for self-suffi- ciency



How to increase green, multi-purpose infrastructure close to villages?

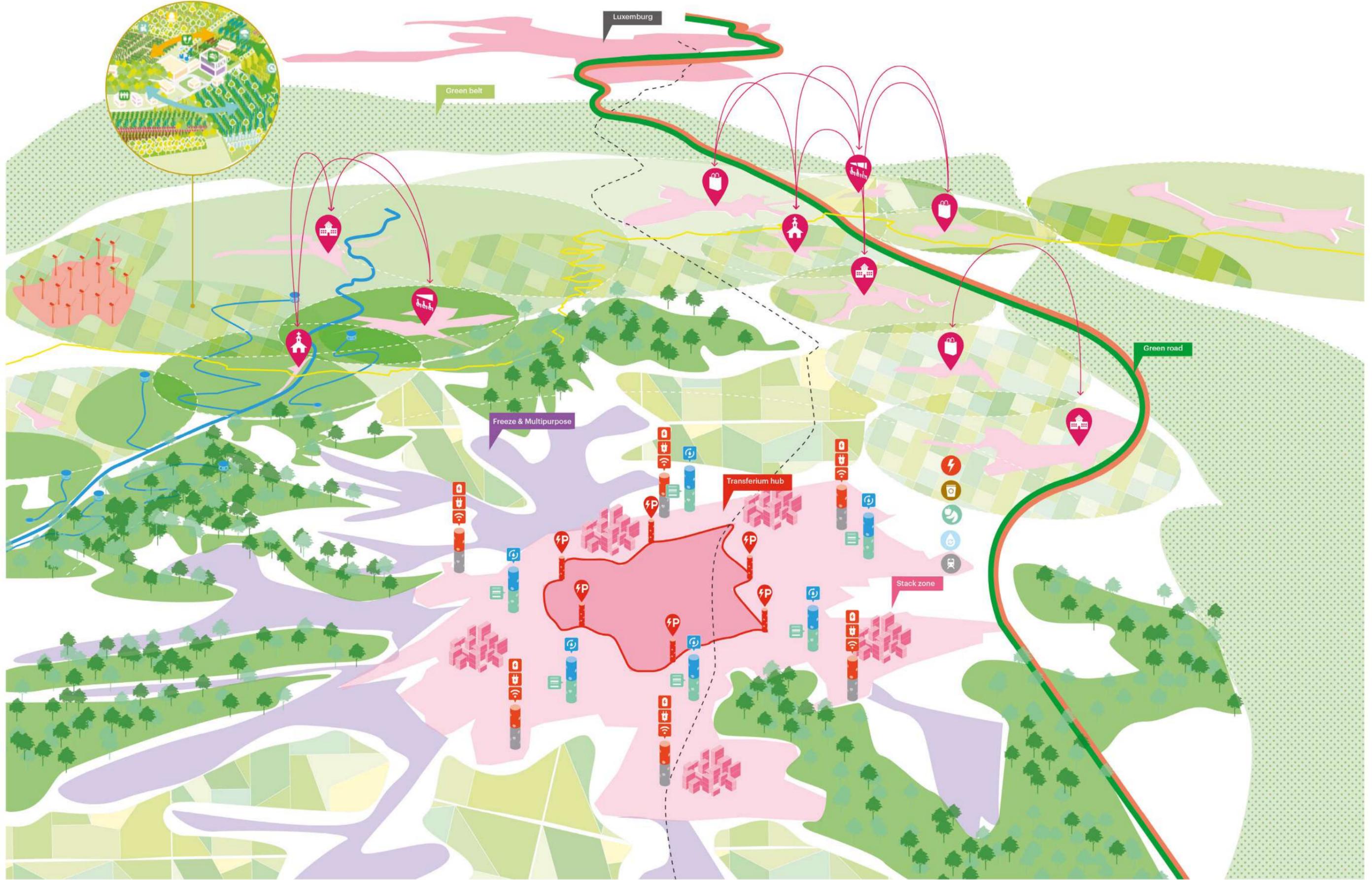
How to balance growth with zero carbon demands?

How to generate healthy dependency on cross-border areas?

How to promote a self-sufficient cluster of villages?

2050

Arlon and cross-border conditions



Next steps

290

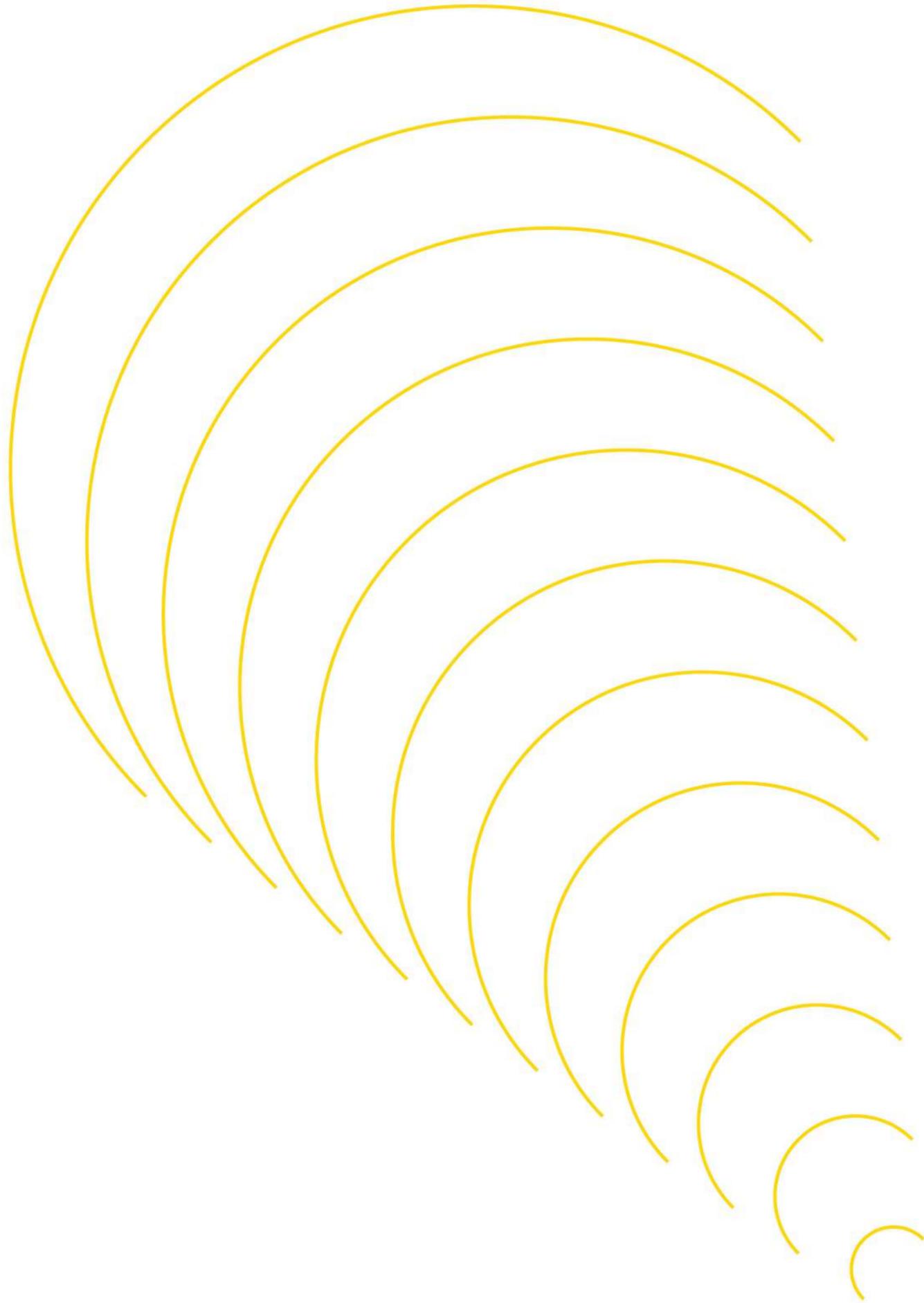
Beyond lux(e) - Stage O2

Next steps

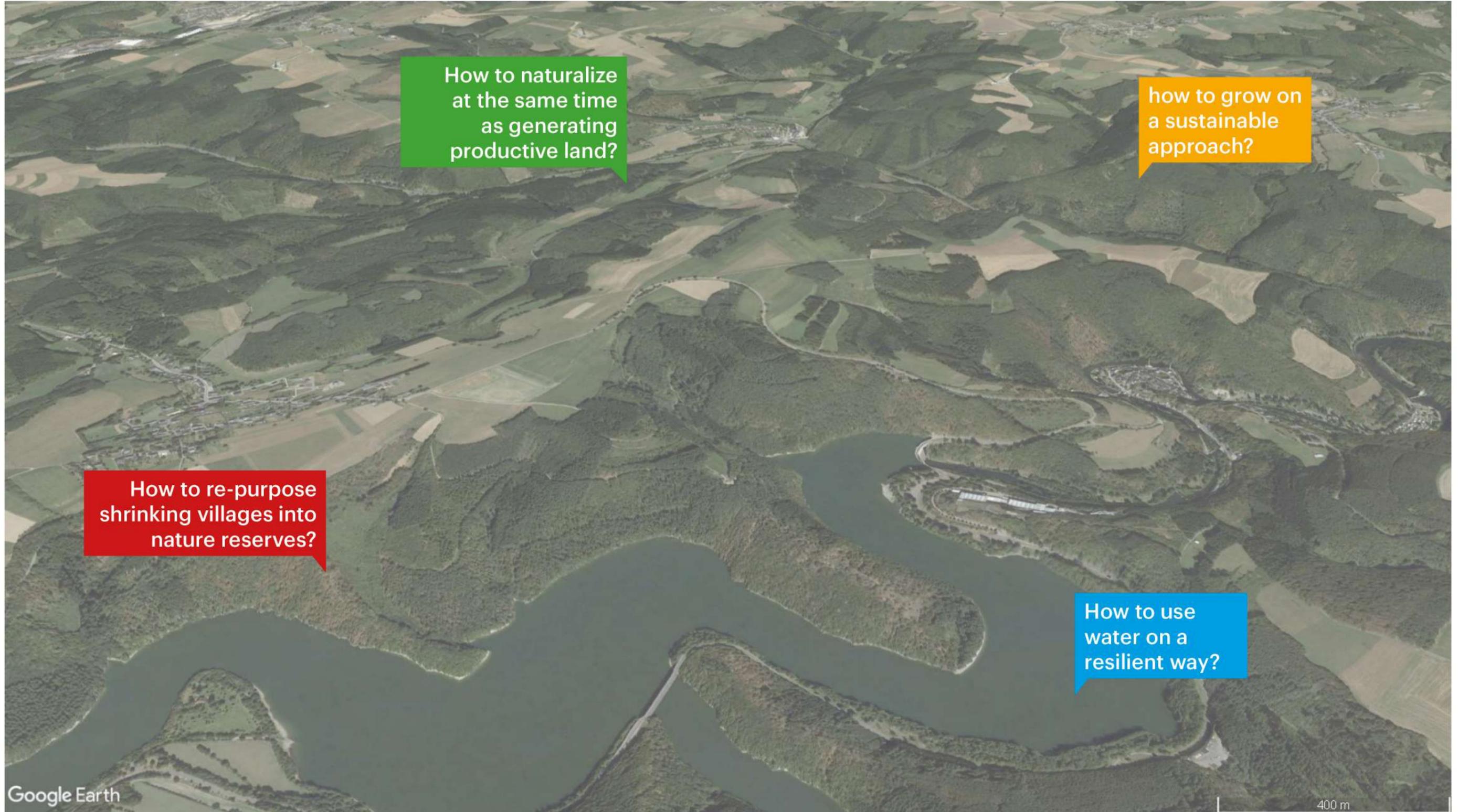
291

Beyond lux(e) - Stage O2





03 Enhancing natural systems



How to naturalize at the same time as generating productive land?

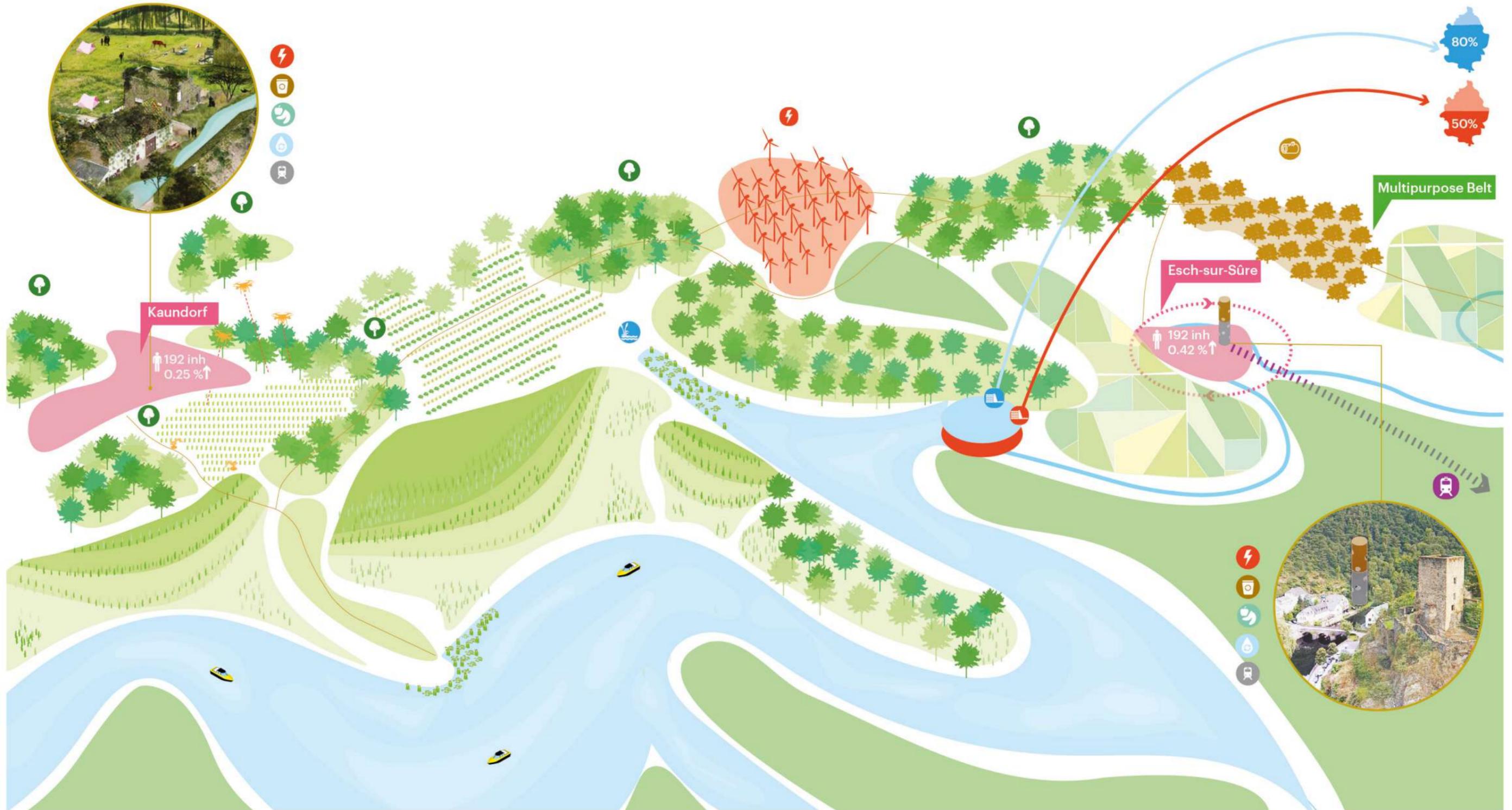
how to grow on a sustainable approach?

How to re-purpose shrinking villages into nature reserves?

How to use water on a resilient way?

Google Earth

400 m







Phase 03

Phase 3 ambitions

Reflections for Phase 3

Phase 2's methodology is a structure that emerges from the combined expertise of the team, tested against expert knowledge and interactions with the committee, as well as Panos and Rosalyne. Beyond this, it facilitates an essential participatory process integrating the efforts of key stakeholders, regional players, and engaged citizens.

In Phase 3: we will endeavour coach the Client to implement this process with local actors in 3 key focus areas to serve as demonstration zones. To do this, we will design a co-production process to further enhance the scenario for the Luxembourg functional area that takes its inspiration from transition governance principles.

The three projects will focus on a detailed test of the decarbonization tool, as a means of validating defined assumptions at the larger scale. Once we have the data, and have drafted the decarbonization proposal, the spatial validation will follow. We hope to get in depth insight into synergies and being able to develop a robust approach that combines quantitative and qualitative strategies.

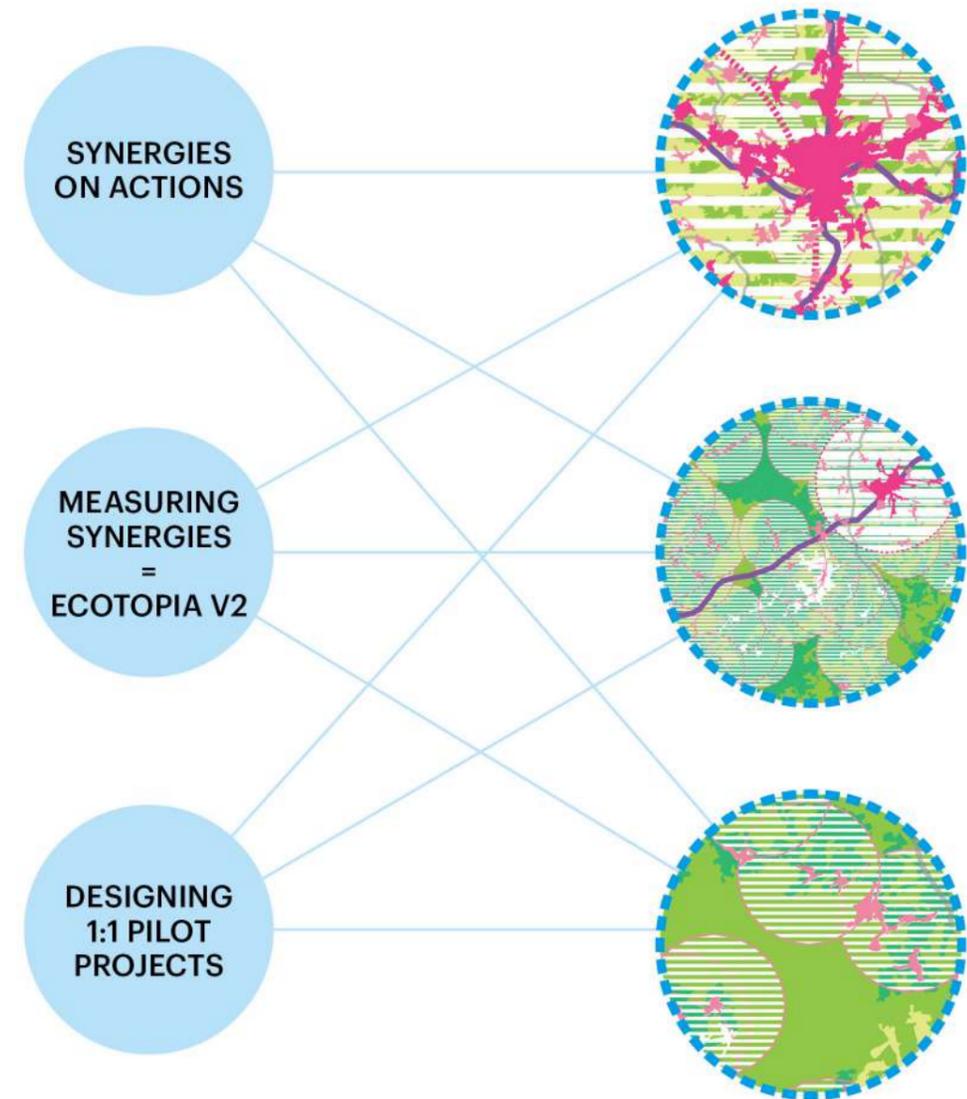
It is necessary to study the three ambitions in a smaller scale in order to address them through fieldwork, accurate calculations, and a 1:1 design. This serves as a validation of assumptions made at larger scale, but also to define methods and strategies in order to scale up and systematize the transition.

Definition and design of synergies: Based on our preliminary vision, we can see where different themes overlap and require either a multi-faceted approach or a stacked approach. This means we need to find the positive and potentially negative effects of coupling themes. For instance, if water and energy come together, what does this look like? What kind of spaces do they need? How do they interact with land use and built environment? What does this shift require from society? How does the coupling strategy ensure a zero carbon and (Re)generative outcome?

Measurement synergies: Once we understand the synergies planned at great scale, and testing them in the three strategic project areas, it is then possible to implement the decarbonization tool further. This will require adjustment and adaptation of our current numeric assumptions, translating them into real and specific numbers related to our three specific areas. Not only is the ambition to validate and adjust the decarbonization tool, but it is also to ensure we will measure and determine the positive and negative measurable effect of our interventions.

Designing Pilot Projects 1:1. Each strategic project allocates a variety of interventions. It is important to design and prove practically on a 1:1 scale how it is possible to implement, execute, and monitor the actions defined in this phase. Many actions will converge in one area, and in this area, we must generate synergy (either a housing tower, infrastructure, or other kind of building) but also even as a process itself. Therefore, this will help us validate assumptions, but also to define strategies for scaling up our interventions.

A governance approach must drive all of the above, meaning that we need to define a collaborative and transition driven Phase 3.



Governance principles for phase 3

The transition management approach proposes six principles for influencing transitions (based on: Roorda, et. al. 2014):

STEP 1: Transition analysis

Obtain insight into the system: We must first acknowledge the complexity of the challenges at hand. This stage investigates the dynamics and interconnections of multiple domains, actors, and scales, by thoroughly examining the existing situation, as well as by questioning assumptions, problem perceptions, and dominant solutions.

STEP 2: Desired future and transition scenarios

In this stage, we aim for system innovation: In small but radical steps, we explore the difference between system optimization and system innovation. We pursue the latter with a long-term perspective, acquired by questioning existing mindsets and an openness to unorthodox ideas and actions. Next, we focus on what needs to be built-up and advanced, also include what needs to be re-built and phased-out. We give space to diversity and flexibility. The future can neither be predicted nor planned, so options should remain open by exploring multiple scenarios (or transition pathways) when working on strategies and actions. Anticipate resistance and barriers, and foster diversity. Involving a variety of perspectives enabling the cross-fertilisation of ideas at this stage prevents 'tunnel vision'.

STEP 3: Co-produce transition scenario with local actors

Emphasize co-production: Neither local, nor national governments, nor any other single actor can address sustainability challenges on their own. A variety of individuals and organizations make decisions that influence the future on a daily basis. As a local government, it is important to engage multiple stakeholders beyond simply soliciting input. Consider every individual relevant to the decision-making process, contributing useful positions and perspectives.

Give room to change agents: Achieving ambitious targets is difficult when vested interests and positions are taken as a starting point. Therefore, seek out actors who are already adopting new or alternative ways of thinking and doing (change agents), as they can be influential in mediating and triggering transitions. Actively engage and support them with the resources and opportunities they need to realize innovations.

Facilitate social and institutional learning: Learning is essential for societal change. Opening up to actors with different backgrounds provides better insights into the challenges of and opportunities for change. The aim is short-term action aligned with a long-term vision to learn about new practices and current constraints. Support learning processes by providing time for reflection and creating a setting that supports mutual trust and openness.

These principles are operationalized in four types of interventions: orienting, agenda-setting, activating and reflecting (Roorda, et. al. 2014):

Orienting includes analysing and positioning oneself (as a city officer) and the municipality vis-à-vis current societal developments and challenges – in the past, present and future – alongside other societal actors. This includes building analytical capacity for transitions.

Agenda-setting includes broadening the discursive and actor network underpinning a common direction. It focuses on creating a shared sense of ownership and ambition for a sustainable future, thereby helping actors to integrate it with their own agendas and practices. This includes building networking capacity for transitions.

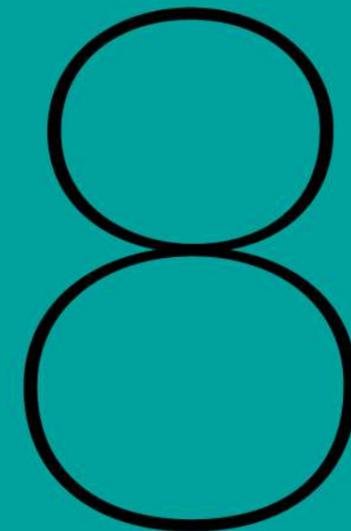
Activating includes putting the shared direction into action by establishing projects and learning from them. Doing this sharpens the orientation and enhances action. This objective also includes building capacity for transitions.

Reflecting includes fostering a culture of reflexivity and learning within the municipality and the city as a whole. It includes learning-by-doing and doing-by-learning, learning from others, and from one's own experiments. Each intervention must build in monitoring and reflection to learn and iterate.

Source: Roorda, C., Wittmayer, J., Henneman, P., Steenbergen, F., van, Frantzeskaki, N., Loorbach, D., Transition management in the urban context: guidance manual. DRIFT, Erasmus University Rotterdam, Rotterdam, 2014.



Colophon



Colophon

Bidding Team



Consultant
Researchers/advisors transition
governance



Main Contractor
Urban + Spatial Planning



Consultant
Landscape design



Sub-Consultant
Sustainability



Sub-Consultant
Mobility & Infrastructure



Sub Consultant
Water Management



Sub-Consultant
Geo-mapping/Spatial
analysis

MVRDV
MVRDV

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