Hypoloop

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Summary:

If we do not anticipate for a transport revolution within 10 years, we are forced back to autarkic ways of life. Transport and our built environment are greatly interrelated. What if we could look at transport from the point of urban development? Is it possible to assess why a mode of transport is right for a city based on an urban impact we wish to establish? These questions rely on understanding transport, demographic change and government policies. The challenge faced is how the energy transition in mobility can serve policy initiatives addressing the decline of population. This thesis is structured in five main chapters: (1) Introduction, referring to aim, scope and methodology; (2) literature review regarding transport revolutions, conditions, effects and future predictions; (3) demographics, trends in the Netherlands, parkstad and related policies; (4) choices in urban development & transport; (5) conclusions and recap findings. This research states the importance of rethinking mobility towards demographic trends.

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Preface
Origen of the thesis and a thank you

The writing of this thesis is a compulsory course in the third semester of studies at the Faculty of Architecture of Delft University of Technology for the Master of Science degree in architecture. It is related to the graduation project concerned with the reassessment of both the Avantis business park and Avantisline public transport, as elements within the Eindhoven-Leuven-Aachen triangle and as part of the south Limburg science campus of Sittard, Maastricht and Heerlen. The graduation project is executed within the Intecture studio of the chair of Architectural Engineering.

I would like to thank my tutors Martijn & Anne for giving me the space and perseverance needed to grasp a challenge of this size. A special mention is due to Thijs Asselbergs for lending me literature and video. Last I would like to thank my pops for helping me get my thoughts on paper in a straight line, and my sister for pointing out the word ‘asses’ might not work as well as ‘assess’ on the first page of your graduation paper.

1. Introduction
Aim, scope & methodology

The Netherlands currently know 20 regions that are, or soon will be, dealing with a decline in population. The municipalities of Zeeuws-Vlaanderen, South-Limburg and North- & East-Groningen are estimated to lose 16% of their population by 2040. The population in an average Dutch region will have grown by 11% in the same amount of time.[1] The decline has a concerning impact on our built environment. City centres increasingly deal with vacancy and municipalities fear an under-participated community. The decline also affects our transport as under-occupancy can force civil services to shut down. The Netherlands spend 550 petajoule on transport annually.[2] The use of energy for transport in Europe is roughly 30% of its total use. Half of this is from passenger cars.[3] As public transport declines more people will turn to individual modes of transport. This could cause energy usage to rise. The energy transition in transport requires more than just electric cars. In pairing the decline of population and the transition of energy in transport originates a possibility to rethink urban development in relation to our means of transport.

1.1 Background of the study

After decades of excessive growth the Parkstad area in Limburg, the Netherlands is currently in decline of population. Throughout the 1960s and 70s, the region was faced with problems caused by the decline of the coal and mining industries. From the start of the 1990s, the region turned itself towards new energy, tourism & recreation, healthcare, smart- and financial-administrative services. In an attempt to stabilise the population by means of reestablishing the purpose of the area there is need for an incentive.[4] In the 19th century, before mining invigorated the region, Heerlen (now labeled as centre of Parkstad) was a fairly isolated village. If people wanted to travel by train they would have to walk to Simpelveld or Sittard, or take the stage coach to Valkenburg, Sittard or Aachen. It wasn't until 1896 that the train tracks from Sittard to Herzogenrath were established. In

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[1] Rijksoverheid (2015). Krimpgebieden en anticipeergebieden. [online] available at: https://www.rijksoverheid.nl/onderwerpen/bevolkingskrimp/inhoud/krimpgebieden-en-anticipeergebieden [accessed 02 Jan. 2017].

[2] CBS (2015). Bewerking van oude reeksen op basis van experts op het gebied van energieverbruik door verkeer en vervoer. CBS, Den Haag/Heerlen. [online] available at: http://www.clo.nl/indicatoren/nl0030-energieverbruik-door-verkeer-en-vervoer [accessed 02 Jan. 2017].

[3] Sijmons, D., Hugtenburg, J., Hoorn, A. v., & Feddes, F. (2014). Landscape and energy : Designing transition. Rotterdam: Nai010 Publishers.

[4] Parkstad Limburg (2012). Working towards a sustainably robust region. [online] available at: http://www.parkstad-limburg.nl/showdownload.cfm?objecttype=mark.hive.contentobjects.download.pdf&objectid=23CAEEFA-09D9-C57D-1189185068FF8293 [accessed 02 Jan. 2017].

1925 the 'Miljoenenlijn' was constructed. The track was given its name because every kilometre built cost a million guilder. This was due to the mining causing a constant threat of land sagging.[5] The infrastructural developments in this region where made possible by the demand of coal. Around the 1900's it became lucrative to export the coal to more inhabited areas, like the randstad, to fuel machines and heat homes. After the rise of cheaper alternatives such as the imported coals from America or the gas-based energy from Groningen, the mines where called to shut down in 1965. The amount of jobs in the region shrunk and people left to seek fortune elsewhere.[6]

Transport is one of the key aspects to our settlement patterns. When the steam locomotive was first used it needed an enormous amount of time to reach speed. This caused the upswing of railroad suburbs where people commuted from. It did however place them a few miles into the countryside instead of at the border of a city. Considering the fact that taking a train was relatively expensive at the time, commuting by rail was something set aside for a middle/upper class society that could afford it.[7] About a century later the Ford factory started to produce a model T every one and a half hour. This was made possible by a moving assembly line. The car became available, and affordable, to the middle classes of America. As more people were free to roam larger distances individually, they expanded away from central urban areas to low-density, mono functional and usually car dependant communities. Apart from the urban effects, suburban sprawl has also led to environmental degradation and intensified segregation.[8] Revolutionary developments in transport often lead to extensive effects in our community and built environment. Would it be possible to approach transport from the point of urban development?

1.2 Statement of the problem

The goal of working on mobility and accessibility is improving international connections, stimulating and facilitating the economic structure, growing employment and improving the liveability and attractiveness of a region.[9] Yet the examples of the steam locomotive and Ford

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[5] ZLSM (2017) Historie van de miljoenenlijn. [online] available at: http://www.zlsm.nl/organisatie/historie/ [accessed 02 Jan. 2017].

[6] Leur, S. van (2017) Historie van de mijnbouw in Limburg. [online] available at: http://www.isgeschiedenis.nl/nieuws/historie-van-de-mijnbouw-in-limburg/ [accessed 02 Jan. 2017].

[7] Wendover Productions (2016). Urban Geography: Why We Live Where We Do. [online] available at: https://www.youtube.com/watch?v=aQSxPzafO_k&index=12&list=PLip8jX-nWCqJRaerDSDAMeyoLKkSWQrO-&t=283s [accessed 02 Jan. 2017].

[8] James, P., Holden, M., Lewin, M., Neilson, L., Oakley, C., Truter, A. & Wilmoth, D. (2013). Managing Metropolises by Negotiating Mega-Urban Growth. In Harald Mieg and Klaus Töpfer. Institutional and Social Innovation for Sustainable Urban Development. Routledge.

[9] Parkstad Limburg (2011). Structuurvisie. [online] available at: http://www.parkstad-limburg.nl/showdownload.cfm?objecttype=mark.hive.contentobjects.download.pdf&objectid=2A3783A9-1517-64D9-CC622D5098E74FB2 [accessed 02 Jan. 2017].

automobile development show it can also create new challenges. New ways of transport have always come as an invention in the quest of improving mobility and its accessibility. This sometimes had radical impacts on urban development. The challenge faced in this research is to combine the policy initiatives addressing the decline of population in Parkstad with the revolutions in transport following developments towards the energy transition.

This thesis analyses transport to find its mutual relation with urban development. Starting with a literary research in transport revolutions, their conditions and their effects. Followed by an analysis of the demographic trend of decline in population in the Netherlands, Parkstad and its related policy. After that we categorise transport modes and relate urban planning to transport through Ebenezer Howard's Garden City methodology.[10] The goal is to highlight the relation of transport to policy and our built environment. Understanding this helps us to take transport as a means to affect our urban environment and answers the question: How can the energy transition in mobility serve policy initiatives addressing the decline of population?

1.3 Summary

This chapter notes the Netherlands are dealing with a decline in population, a set back in the energy transition and the fact that both challenges are related to transport. The goal of working on mobility and accessibility is improving international connections, stimulating and facilitating the economic structure, growing employment and improving the liveability and attractiveness of a region. Transport is one of the key aspects to our settlement patterns. This research aims to answer the question: How can the energy transition in mobility serve policy initiatives addressing the decline of population?

[10] Howard, E. (1902). Garden Cities of To-morrow (2nd ed.). London: S. Sonnenschein & Co, pp. 2–7.

2. Trending transport
Key developments & urban impact

The history of transport is largely one of technological innovation. Advances in technology have allowed people to travel farther, explore more territory, and expand their influence over larger and larger areas. Even in ancient times, new tools such as foot coverings, skis, and snowshoes lengthened the distances that could be travelled. As new inventions and discoveries were applied to transport challenges, travel time decreased while the ability to move more and larger loads increased. Innovation continues as transport researchers are working to find new ways to reduce costs and increase efficiency. This chapter discusses previous revolutions, our current condition and a plausible near future development for transport. Dimensions in the quality and demand of transport are stated. Current modes of transport are compared and the necessity for new modes is explained.

2.1 Transport revolutions until now

'There have been two kinds of change in human mobility since hominids began exploring the African savannah: incremental change and revolutionary change.'[11] Incremental means a change that has grown over years of time, something we adapt and improve little by little. 'A transport revolution is a substantial change in a society's transport activity that occurs in less than 25 years.'[12] Gilbert & Perl identify five of these changes in our history:

- Britain's railway revolution of 1830 to 1850
- Great wartime pause in motorisation in the US
- Big switch in transatlantic travel in the 1950s
- High speed rail revolution of 1960 to 1985
- Air freight revolution of 1980 to the present

It is noted these changes are not simply the invention of a mode of travel, but rather the big behavioural impact that relates to it.

[11] Gilbert, R., & Perl, A. (2010). Transport revolutions : Moving people and freight without oil (Rev. and updated ed., [2nd ed.].). Gabriola Island, BC: New Society. pp13

[12] Gilbert, R., & Perl, A. (2010). Transport revolutions : Moving people and freight without oil (Rev. and updated ed., [2nd ed.].). Gabriola Island, BC: New Society. pp14

Britain's railway revolution of 1830 to 1850

As the industrial revolution caused a steep rise in production, the growing global trade developed a necessity for the transport of large volumes of goods. The capacity of the canal transport at that time did not rise adequate to the growth of freight transport. In order to meet the growing demand the steam locomotive was believed to be a faster and cheaper way of connecting the Atlantic seaport of Liverpool to the land inward industrial production city of Manchester. The thought of using a locomotive was made possible by the invention of the steam engine. An internal combustion device used to burn wood and coal to power machines. When the locomotive was first put to use in 1830 the revenue turned out quite different from expectation. Only 12% of freight in tonnes was transported by rail in the first six months, yet more than twice the amount of expected passengers. The train more than quadrupled passenger travel from 108.000 to 460.000 people in the first year. This in turn forced not the canal transport, but rather the coach operators to change their business strategy. They would shift to intercity operations from the train station to other places in the city, transporting passengers and smaller amounts of goods.[13]

This revolution shows us that the intent and outcome of a new mode of transport can differ considerably. It also shows already existing organisations of transport are not so likely to quit but rather reposition their service and take the chance to develop a new business model. 'A belief that existing transport is inadequate and that major improvements are required can be a key factor spurring the investment and risk-taking required to launch revolutionary new mobility.'[14]

Great wartime pause in motorisation in the US

The first model T's came off Ford's assembly line one year before the start of the great war. What the steam engine meant for the train is surpassed by what the petrol engine did for cars. By 1941 Americans owned about three quarters (30 million) of all the cars in the world. Automobiles used 80% of all rubber in the country.[15] The intake of resources caused the US military to be unable to meet productions needed for the war. The attack on Pearl Harbour caused the government to call for an acute stop on car production. Personal vehicles off US assembly lines dropped from 3.8 million in 1941 to 143 vehicles in 1943. As the access to natural rubber was cut off by the Japanese, gasoline also had to be rationed because the war constrained the transport of fuels along the Gulf and West Coasts. It is the scarcity of these two resources that forced Americans to dramatically

[13] Gilbert, R., & Perl, A. (2010). Transport revolutions : Moving people and freight without oil (Rev. and updated ed., [2nd ed.].). Gabriola Island, BC: New Society. pp15

[14] Gilbert, R., & Perl, A. (2010). Transport revolutions : Moving people and freight without oil (Rev. and updated ed., [2nd ed.].). Gabriola Island, BC: New Society. pp15

[15] Donald M. Nelson (1946). Arsenal of Democracy. New York: Harcourt, Brace, and Company.

rethink personal transport on the mainland. A ban on recreational driving was imposed in 1943. Even though there were about 6 cars to every 7 households at the time, the majority did not consider the car to be essential to daily life.[16] The events of the war led to a surge in public transport from 13 billion in 1940 to 23 billion trips in 1946. As the war came to an end the primary focus of the government was to prevent a recession. They learned this from the ending of the first world war. The prevention translated into a plan to transform all military production to that of consumer purchasing goods. Many of the plants and workers were well suited to adjust to the production of cars and soon the economy was on its way. Where public transport peaked at 23 billion trips in 1946, it depleted to 9 billion in 1960 and a mere 6.5 million in 1971.

This revolution shows us that we can be greatly adaptive in times of necessity. In a time of war the government discouraged the production of cars, sparking an increase in public transport usage as a direct result. 'Government can be a prime instigator of a transport revolution.'[17]

Big switch in transatlantic travel in the 1950s

Controllable flights through the air have been around since the Wright brothers in 1903. As the aircraft was coined as a weapon in the first World War developments to propeller and body excelled. During World War II the development of kerosene based jet engines for fighter jets, and bigger bodies for bomber planes allowed for new commercial ways to cross the seas. The bombers required longer landing strips and made it possible to fly above anti aircraft guns, and in doing so, above bad weather conditions. The jet engine increased speed. Combined with a bigger body planes eventually packed enough fuel for the first commercial Boeing 707 to travel from New York to Paris in 1958.[18][19] Ships were the only way to cross the Atlantic seas up until the flying boats in the 1930s. As aviation took flight after the second world war passenger transport by sea redeveloped its strategy. The cruise ship was reinvented, going from a means of transport to travelling with entertainment value, facilitating a more spacious and luxurious alternative to cramped planes. The transport of goods was disconnected and became its own shipping line entirely.[20]

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[16] Gilbert, R., & Perl, A. (2010). Transport revolutions : Moving people and freight without oil (Rev. and updated ed., [2nd ed.].). Gabriola Island, BC: New Society. pp29

[17] Gilbert, R., & Perl, A. (2010). Transport revolutions : Moving people and freight without oil (Rev. and updated ed., [2nd ed.].). Gabriola Island, BC: New Society. pp33

[18] Boeing (2008). Seventh Heaven: 50 years ago, Boeing and Pan Am revolutionised travel with the 707. [online] available at: http://www.boeing.com/news/frontiers/archive/2008/july/i_history.pdf [accessed 02 Jan. 2017].

[19] AVjobs (2017). History of Aviation. [online] available at: http://www.avjobs.com/history/ [accessed 02 Jan. 2017].

[20] Jobmonkey (2016). Cruise Industry Trends From the 70s to 90s. [online] available at: http://www.jobmonkey.com/cruise/necessity_to_pleasure/ [accessed 02 Jan. 2017].

This revolution shows us how technological advancement from the war can later benefit commercial parties. It also shows how the industry of moving people across seas by ship has redeveloped their strategy to better serve a certain need.

High speed rail revolution of 1960 to 1985

As the motor and aviation industries took off there was a period where many believed that the passenger train was done with. A new rail line between Japan's biggest cities Tokyo and Osaka, the Shinkansen, had been approved in 1939, started construction in 1941 and was bombed in 1944. In 1949 the Japanese National Railway emerged as a public corporation and continued the project. Japan intentionally set its industrial trajectory away from aerospace and military production. Their top electrical, mechanical and civil engineers were drawn to the Railway Technological Research Institute. In order to compete with developments in the other transport sectors there was need to reassess the values that rail transport could bring and establish something useful and rational for a longer time into the future. Instead of trying to serve all mobility needs at the same time, they had learned from the strategy developed for aviation. Position your niche in the market. Faster than a car, but also cheaper and more frequent than planes. Powered by electricity and set ideally for 200 - 1000 km distances.[21]

This revolution shows the power of government and industry working together in order to redevelop a way of transport and its strategy to become relevant again. It also notes the importance of setting a clear target and niche within the industry of transportation services.

Air freight revolution of 1980 to the present

Before this revolution air freight was largely overshadowed by passenger transport. All schedules and flights were fit to passengers and air freight moved only on these planes. It was not until Fred Smith from Arkansas Aviation Sales thought of moving the cargo on dedicated planes connected with a door-to-door delivery system that change was due. The Federal Express found clientele in all product offering services wishing to add fast delivery services. In little time bar-code labels were applied and the modern package shipping and tracking services came to be. Companies like UPS, TNT and DHL soon followed. Air transport offers an effective just-in-time delivery for both inputs and finished products to companies and customers. It reduced the need and risk of inventory and set the stage for the growth and importance of E-commerce in a global economy.[22]

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[21] Gilbert, R., & Perl, A. (2010). Transport revolutions : Moving people and freight without oil (Rev. and updated ed., [2nd ed.].). Gabriola Island, BC: New Society. pp33

[22] Gilbert, R., & Perl, A. (2010). Transport revolutions : Moving people and freight without oil (Rev. and updated ed., [2nd ed.].). Gabriola Island, BC: New Society. pp56

This revolution shows what impact a visionary entrepreneur can have in the development of our use of transport.

What can urban planning learn from transport revolutions?

These revolutions show us a number of things. The intent and outcome of a mode of transport can differ considerably. Already existing organisations of transport rarely quit but rather reposition their service and take chances in developing new business models. A belief that existing transport is inadequate and that major improvements are required can be a key factor spurring the investment and risk-taking required to launch revolutionary new mobility. We can be greatly adaptive in times of necessity. Government policy can be a major instigator of change. Alternative means like public transport are able to adapt quickly in response. Technological advancement made by the government at war time can lead to technological advancements later benefitting commercial parties. There is great potential in governments and industries working together in order to redevelop a way of transport that is once again relevant. All it takes is one visionary entrepreneur. Taking an even closer look, there are additional learnings to be noted here. Revolutions can have a high degree of unpredictability in their immediate outcomes. Change can move quickly. Moving faster exerts a powerful attraction, especially when the cost of such speed is no more than that of moving more slowly. When mature organisations and established technologies are redesigned to yield higher performance, the resulting revolution can unlock significant amounts of hidden value within the transport system. Changing the relationship between transport modes can yield just as big of a difference as introducing organisational and technical innovations to a single mode. In short we find:

- It is never just technological innovation that sets a revolution in motion. It is a combination of circumstances in multiple domains such as the political, economic and social. Therefore a comprehensive approach is needed.
- Governmental policies can be prime instigator in developments. The government is also a prime player in Dutch urban development. This opens up new changes and responsibilities.
- Changes in transport can move quickly and disruptive. Urban planning sometimes remains unaltered decades after its realisation. Consequently, anticipation of the next transport revolution is an absolute must for parties involved in the establishment of our long term built environment.

2.2 Transport today

Now that we have discussed revolutionary change in our history of transport we can look into what comprises our transport currently. Transport can be valued in four ways. How many people use it (scale), the time it takes to the distance traveled (speed), how much it costs (efficiency) and how easy it can be used (accessibility). In order to better understand how these dimensions interrelate they will be discussed through three oppositions.

Local vs. global

In order to understand our transport a split should be made in local and long-distance. only 2.1% of trips of US residents in 2001 where more than 80km. Yet this did make up for 29% of total person-kilometers.[23] The cross-size of cities has long been determined by distance traveled. Medieval Paris ranged 5 - 8 km, as public transit was introduced it went up to 20 - 30 km and with the widespread acceptance of cars cities would range 50 - 60 km. What this example actually shows is that beyond distance, time is actually key in understanding what is considered local in our settling.

brief vs. enduring

Distance traveled can be measured in time. There's a constant found in the travel-time budget that shows people are content to travel approximately one to one and a half hour every day.[24] Within this time dynamic they will organise daily or weekly necessities accordingly. As a determining factor the average speed of travel can set up the boundaries of distance.[25] If we suppose a destination at half an hours travel, distances would range: 2.5 km on foot, 9 km on bike, 60 km by car, 55 km by train, 140 km by TGV and 450 km by plane. Considering most Americans prefer to travel by car this adds up to the local scale of 80km. But as time can include delay from traffic jams, bus stops, boarding a plane and other events it should be accounted all travel will be less distance. For this reason travelling by plane for a trip as little as half an hour is not even possible. When discussing time in travel it is very important to include every aspect from door to door.

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[23] Gilbert, R., & Perl, A. (2010). Transport revolutions : Moving people and freight without oil (Rev. and updated ed., [2nd ed.].). Gabriola Island, BC: New Society. pp88

[24] Marchetti, C. (1994). Anthropological Invariants in Travel Behavior, Technological Forecasting and Social Change , 47 : 75--88, Internal Publication, International Institute for Applied Systems Analysis, Laxenburg, Austria

[25] Gilbert, R., & Perl, A. (2010). Transport revolutions : Moving people and freight without oil (Rev. and updated ed., [2nd ed.].). Gabriola Island, BC: New Society. pp88

personal vs. general

An other way of looking at our transport is the reach of our modes. The simple approach to this is private as opposed to public transport. Private, or as I would rather call it personalised, accounts for door to door transport at precisely the time you need it. Public (or rather general) means are point to point at certain set times (e.g. every 15 minutes). Similar to a train leaving a station. Beyond this point to point system is the possibility of a spoke hub distribution. A hierarchical network of different modes of transport connected to each other. These lines of buses, ferries and trains form a set grid of access and connectivity. If you are not within walking distance of theses lines (either at start or end of your trip) you need a personalised mode of transport to bridge the gap. I believe that allowing this gap turns people to personalised transport. When one is already using personalised transport you are likely to keep using it. As long as there are no differences in travel time or cost. Better yet when you own a personalised type of transport requiring additional owning costs the financially best option is to use it as much as possible. Owning a car in that sense might give freedom in movement but reduces freedom in choice (and thus adaptability/flexibility) of transport. This aspect is greatly influenced by time, comfort, and financial cost.

What can urban planning learn from transport today?

The most important factor in settling is the daily travel time. As our modes of transport develop we change our traveling speeds. This changes the notion of local due to the travel-time budget. Owning a mode of transport can greatly reduce our adaptability, objectivity and inso doing the development, of modes of transport. What also influences transport is the travel path of the mode of transport. As general transport requires a certain occupancy to retain economic feasibility and energetic efficiency its network does not always reach every individual. Therefor the hierarchical network will always need a viable 'off-grid' alternative to complement in the total of transport. For parties involved in the establishment of our long term built environment there is a lot to learn from transport today. In this research there are two points to round up.

- For urban planning there are three major oppositions that have to be accounted for. These need to be balanced both individually and together.
- Urban planners have to take in account the possibility of future changes in transport. There is a necessity for flexibility and anticipation towards change.

2.3 Towards a new transport

All modes of transport that have to deal with resistance or friction, such as wind or the wheels on the tarmac, require a constant input of energy to maintain velocity. Moreover, every vehicle needs input of energy to accelerate. The transition that lies ahead is that of changing from conventional towards renewable energy. The efficiency of a mode of transport can be measured in energy required to move one person one kilometre: MJ/pkm. As the steam locomotive and even the first cars were steam powered, coming from the burning of coals, modes would carry an internal combustion engine depending on fuel for their propulsion. These fuels have, until recently, always been of a depleting resource. We went from wood, coal, natural gas to oil. It is estimated that we have used half of the total amount of available oil in the world. The first quarter took 46 years, roughly from 1940 to 1986, the second quarter took only 22 years. Our pace of oil usage currently is even bigger. Following oil scarcity there are two likely transport revolutions to happen within the coming 25 year window. We either reduce transport to a bare minimum or we find a way of transport based on a different energy source. The best prediction is the use of electric vehicles. Alternatives like biofuel and hydrogen will not be able to meet the scale of our current transport. In this transition to electric powered transport the demand for power will grow greatly and extra means of producing both solar and wind energy will need to be implemented.[26] Not all modes of transport will be able to work on electricity. This is why the development in areas of fuel-efficiency, biofuel and hydrogen are still important. Electric power is not ideal for long distance off grid and heavy load traffic. Areas where biofuel and hydrogen could prevail. In the transition of energy sources for transport there is a clear need for distinction between the function of transport, its best suitable source of energy and different types of urban situations.

Predicting the scene for 2025

It is highly likely one of two basic transport revolutions is about to happen within the next few decades. The first would be that transport activity will decline substantially, either due to economic recession or oil depletion. The other is a maintaining of transport activity but increasingly using means of transport that do not rely on oil. The industry's main focus is on this second revolution. The year 2025 provides a close enough target that could motivate action. It gives us an 8 year period within which we'll be able to attain significant results from redesigning transport systems as well as aid us in setting the trajectory rather than merely an end goal.

[26] Sijmons, D., Hugtenburg, J., Hoorn, A. v., & Feddes, F. (2014). Landscape and energy : Designing transition. Rotterdam: Nai010 Publishers.

In the Netherlands the percentage of renewable energy as part of the total energy market in 2016 was 6.3%. This is still down more than 13% from the European 2020 goals.[27] In the EU gas emissions in the transport sector have actually increased by 8.3% from 1990 to 2014.[28] As a result the EU has recently passed legislation that requires new cars to not emit more than an average of 130 grams of CO2 per kilometre by 2015. By 2021 the achievable average is 95 grams of CO2 per kilometre. This target represents a reduction of 40% respectively compared to 2007 (when electric cars first entered the market). Roughly translated this means European car manufacturers are forced to turn the market share of electric cars from 1% to about 10% within the next 3 years. It took us 8 years to reach the first percent.[29] How can we speed up this process towards the electric transport revolution? To answer this question we need to look deeper into the different modes of transport.

Domains of transport

The transport modes we have discussed can be categorised in a number of ways. Below is an overview of transport modes related to their energy source.

energy source / modes	bicycle	car	bus	?	tram/ metro	train	high speed rail	?	airplane
man power	X								
gas		(x)	(x)						
oil		X	X			(x)			X
hydrogen		(x)	(x)			(x)			
biofuel		(x)	(x)			(x)			
electricity		(x)	(x)		X	X	X		

Illustration 1: Table showing modes of transport and energy they run on

The overview shows most modes already have been modified to work on electricity. The airplane is having difficulty to adjust to other energy sources due to the level of energy in relation to weight/volume. The car and bus are slower to adjust partly due to the lack of infrastructural adjustments needed to power them. The following theoretical model on our approach towards the

[27] Visser, M. (2015). Renewable energy in The Netherlands. May 2016. [online] available at: http://en-tran-ce.org/wp-content/uploads/2015/07/Renewable-Energy-in-NL-May-2016.pdf [accessed 02 Jan. 2017].

[28] Eurostat (2016). Greenhouse gas emissions, analysis by source sector, EU-28, 1990 and 2014 (percentage of total) new. [online] available at: http://ec.europa.eu/eurostat/statistics-explained/index.php [accessed 02 Jan. 2017].

[29] European Commission (2016). Reducing CO2 emissions from passenger cars. [online] available at: http://ec.europa.eu/clima/policies/transport/vehicles/cars_en#tab-0-0 [accessed 02 Jan. 2017].

transition of energy in transport can be made.

energy / modes	contemporary	new
fossil fuels	Our existing modes of transport, some dating back more than a hundred years.	Increasing the efficiency of our existing modes of transport so we can last longer with the finite supply of fossil fuels.
renewable energy	Converting our existing modes of transport so they can be powered by renewable energy sources.	Developing a new mode of transport from a perspective on the future of mobility based on renewable energy.

Illustration 2: Table showing four strategies related to the energy transition

Since the industrial revolution we have relied on fossil fuels to power our transport. Two-hundred years later we are standing at the crossroads of fuel scarcity and the potential of renewable energy. On one hand we keep developing technology for conventional modes of transport to make them more fuel efficient. On the other we electrify all conventional modes of transport that we currently know. A third step is to develop new modes of transport. Modes that are built for renewable energy and consider our total usage of energy for transport. This requires a rethinking of the means and purpose of transport. This cannot be done overnight. What we can do is reassess the dimensions of transport in such a way that we set up a framework of future demand of our modes.

In the previous overview I placed question marks in order to propose the necessity of two new modes of transport. One regional and one international. Elon Musk first mentioned the concept for a 'fifth mode of transport' in July 2012. This hypothetical high-speed mode of transportation would have the following characteristics: immunity to weather, collision free, twice the speed of a plane, low power consumption, and energy storage for 24-hour operations. Although Musk himself is not developing the transport, he is interested in helping to accelerate development of a functional 'Hyperloop' prototype. Current predictions are the electric powered transport will travel at about 1200 km/h and a pod carrying 15 to 20 people will leave every .5/2 minutes. It is expected to be most efficient under 1000km distances. Over 1000km a plane will be better.[30] Musk is a pioneer in electric transport. As he grew aware of our issues with fuel he understood an alternative to aviation has to be development within the next 10 years.

Why is an alternative needed on regional scale? There are a number of aspects in which the car, bus and metro are inadequate modes of transport. The amount of cars should never have grown to this scale. Most Dutch cities will be clogged up by 2021. Municipalities should actively discourage car use in cities.[31] Moreover cars are theoretically still the most inefficient mode when looking at

[30] Pensky, N., Lacy, S., Musk, E. (2012). Pando Monthly Presents: A Fireside Chat with Elon Musk. Pando Daily/YouTube.com. Event occurs at 43:13. Retrieved December 11, 2016.

[31] Maessen, L. (2016). Mogelijk 'verkeersinfarct' grote steden in 2021. [online] available at: https://www.nrc.nl/nieuws/2016/12/28/mogelijk-verkeersinfarct-grote-steden-in-2021-a1538633 [accessed 02 Jan. 2017].

energy required per person-kilometer. Unfortunately buses and metro's often proof more inefficient in MJ/pkm as their occupancy rate outside rush hour can be as low as 30%. A big problem with rail transport are the high investment costs related to infrastructure. These are often spread over a long period of return on investment. This makes it difficult to adapt to demographic changes set to happen in a few years. The regional scale needs a mode of transport that carries small groups, is adaptable in capacity and infrastructure, has a low energy use, has low investment costs and a low period of return on investment. In order to better understand this mode of transport we need to better understand the region.

What can urban planning learn from / draw on the future of transport?

Oil is a finite source. If we do not change our usage we will have used most of it before 2040. The transition that lies ahead is that of changing from conventional towards renewable energy. On one hand we keep developing technology for conventional modes of transport to make them more fuel efficient. On the other we electrify all conventional modes of transport that we currently know. A third step needed is to develop new modes of transport. Modes that are built for renewable energy and consider our total usage of energy for transport. To round up:

- The energy transition is unavoidable. When regarding transport it is also evident to happen in the period up to 2040. It is necessary to anticipate for this revolution in our urban planning.
- In the transition to electricity our modes of transport need adjustment in scale and efficiency.
- New modes need to developed on international level as an alternative to aviation and on a regional level as an alternative to the car, bus and metro.

3. Demographics
Decline in population & policies

The Netherlands currently know 20 regions that are, or soon will be, dealing with a decline in population. The municipalities of Zeeuws-Vlaanderen, South-Limburg and North- & East-Groningen are estimated to lose 16% of their population up to 2040. The average Dutch region will have grown in population by 11% in that same time.[32] This chapter takes a closer look at the demographics in the Netherlands and specifically in Parkstad, Limburg. Next we take a look at the local policies that have been set to address the decline.

3.1 Demographics of the Netherlands

The central bureau for statistics (CBS) has detected a number of trends and turns in the demographics of the Dutch population. Our overall population is growing. This is related to the fact that our average life expectancy is extending. There are currently four 'major' cities experiencing considerable growth. CBS also states three shrink regions.

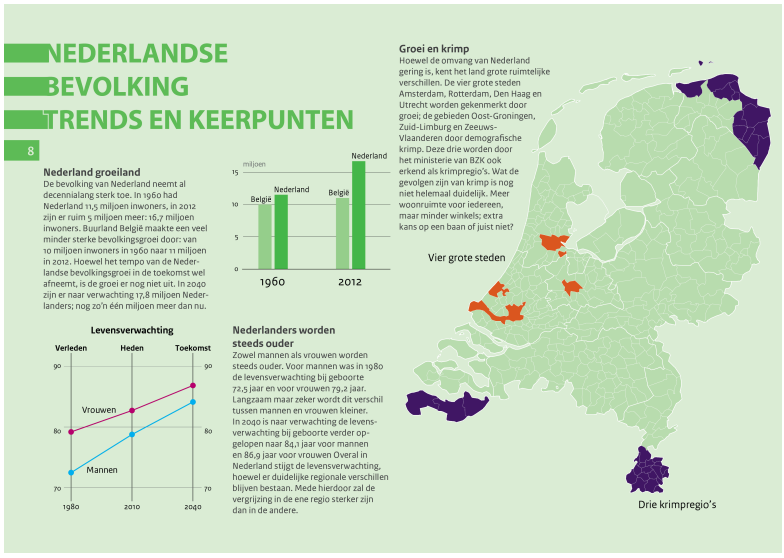


Illustration 3: Trends and changes in Dutch Population

When we take a closer look at the shrink regions we find an important occurrence in the expected population. The rise of the average age is a trend all over the Netherlands. This means we relatively have more elderly than we did before. The following graph shows that these different age classes also have a different settling pattern. As younger people are drawn to the proximity of the

[32] PBL & CBS (2014). Nederlandse bevolking trends en keerpunten. [online] available at: http://www.pbl.nl/infographic/nederlandse-bevolking-trends-en-keerpunten [accessed 02 Jan. 2017].

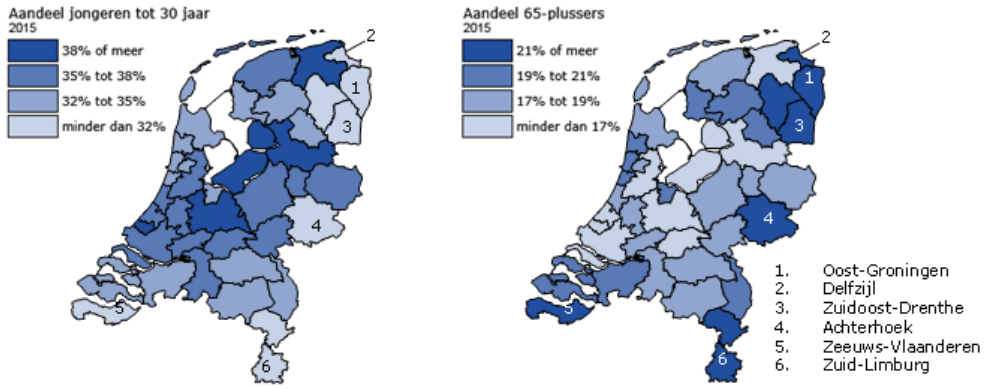


Illustration 4: Population share of ages <30 and >65 in the Netherlands

four major cities we can see the 'Randstad' take shape as the economic centre of the country. On the other hand this image shows that the area of South-Limburg is not only dealing with decline but also with the ageing of its population. When considering these three shrink areas there are differences. As the chart of age shows Groningen is actually concentrating around the city centre as many younger people settle there. Zeeland and Limburg are comparably losing their younger population as the share of elderly people grows. We find what separates these regions more distinctly when we look at jobs.

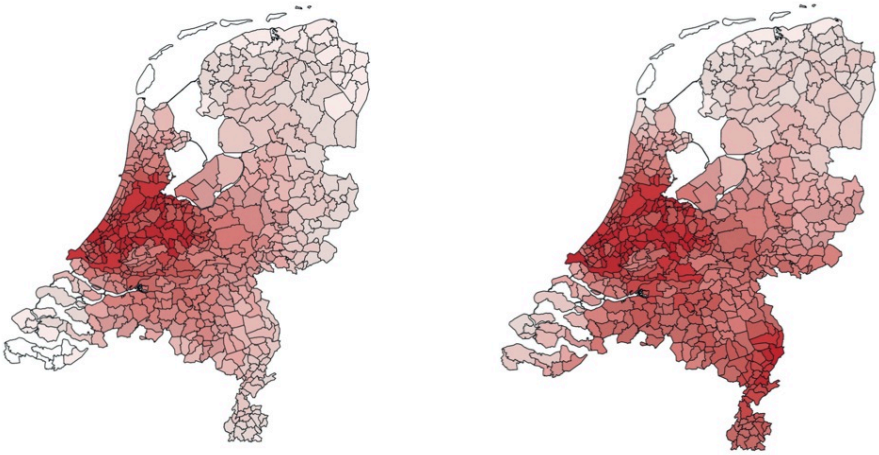


Illustration 5: Location of jobs reachable in an hour within and across borders

What makes Limburg extra interesting is that the amount of jobs reachable within the hour is at par with the Randstad, the major economic region of the Netherlands. These jobs are mostly across the border in either Germany or Belgium. To better understand what is happening in Limburg we will look closer at the Parkstad region.

3.2 Demographics of Parkstad

Parkstad is a joint effort of a number of municipalities to create a strategy that better addresses the changing situation in the region. After decades of excessive growth the Parkstad area in Limburg, the Netherlands is currently in decline of population. Throughout the 1960s and 70s, the region was faced with problems after the decline of the coal and mining industries. The current estimation is a further decline of 25% average in the period of 2005 to 2035.

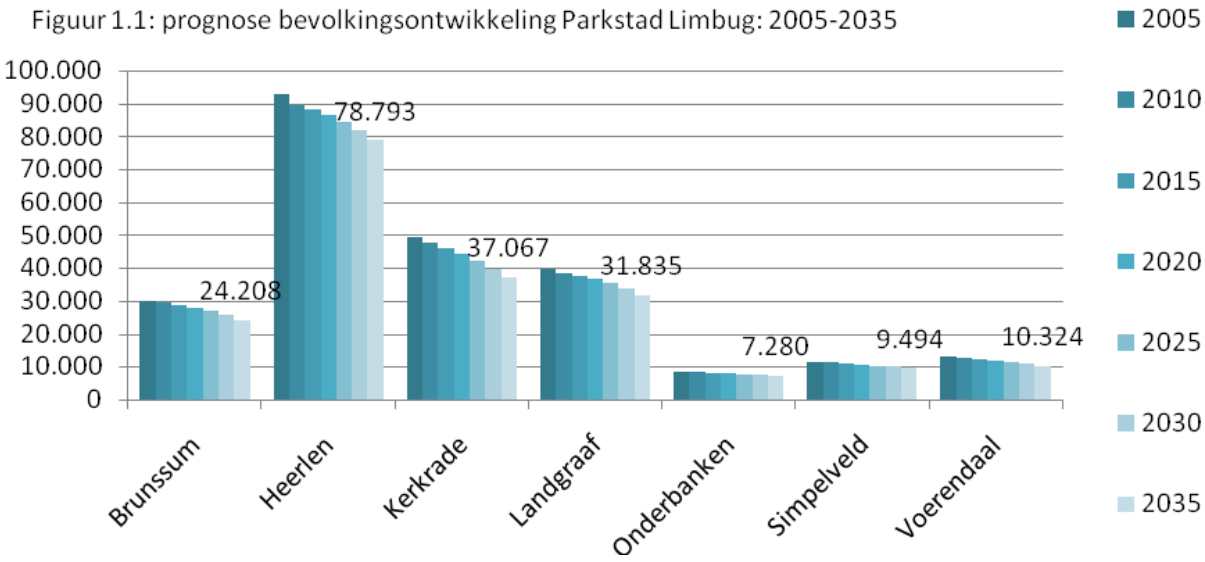


Illustration 6: Anticipated development of population in Parkstad Limburg

What seems strange is that the surrounding regions crossing over to Germany and Belgium came from a similar history of mining yet they continue to grow in population.[33]

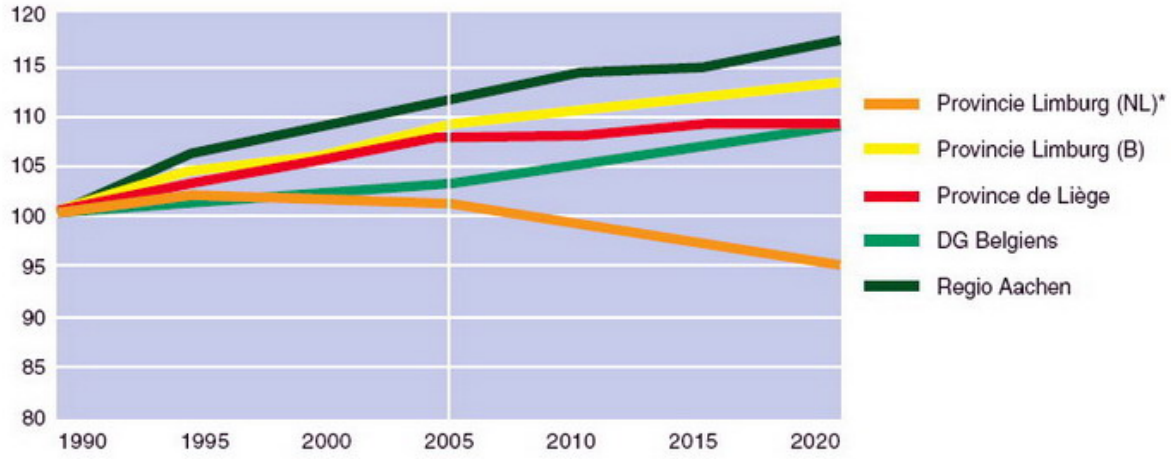


Illustration 7: Development of population in Limburg and surrounding provinces

[33] EIS (2016). Bevolkingsontwikkeling deelgebieden Euregio Maas-Rijn. Euregio Maas-Rijn in cijfers, p.19 [online] available at: http://forum.mestreechonline.nl/forum/mestreech-maastricht/maastricht-2025-grote-projecten/1880-krimp-nu-is-het-afgelopen [accessed 02 Jan. 2017].

3.3 Policies addressing decline of Parkstad

Parkstad advisors have determined the decline of population as substantial and structural in both the number of people and households at a regional scale level. This decline has considerable consequences for the level of amenities and the economic perspective of the region as it will face a loss in value.[34] The advice given constitutes, among others, the following:

- Complete the financial overview of the demolition and transition of housing.
- Terminate plans for new housing and business parks.
- Develop a joint housing vision on Parkstad scale including transition plan and financial arrangements.
- Improve the follow-through of regional housing visions to municipal designation plans.
- Translate recommendations of education to concrete actions and start the process.
- Broaden the strategic agenda with subjects like education, healthcare, culture, wellbeing and labour market. include what connections of mobility are needed to connect Parkstad region to economic centres such as Maastricht, Eindhoven, Venlo, Leuven and Aachen. Invest in mobility to benefit the quality of education healthcare and wellbeing.
- Develop a concrete plan of execution based on the above stated agenda including financing and demonstrate what part can be paid for by the region itself.
- Produce an overview together with healthcare and wellbeing institutions showing what amenities are needed at what scale and show the financial consequences of the decline.
- Include the corporate world more explicit in discussion on the decline.

The regional agenda of Limburg has set up four core ambitions for Parkstad: [35]

- Strengthening the economic profile.
- Intensifying connectivity; robust networks within and across borders.
- Capitalising on the quality of life in the region.
- Facilitating a higher level of human capital and labor potential.

The region of South Limburg is currently facing serious decline. The prospects up to 2040 show no change. When compared to the neighbouring regions in Germany and Belgium this shows a extraordinary situation. Apparently the conditions for growth are present in this area yet Parkstad seems unable to capitalise on them. Numerous research and policy initiatives are already on the

[34] Dijkstal, H.F. & Mans, J.H. (2012) Krimp als structureel probleem. [online] available at: http://www.vanmeernaarbeter.nl/sites/vanmeernaarbeter.nl/files/Rapportage%20Topteam%20Krimp%20Parkstad%20Limburg.pdf_0.pdf [accessed 02 Jan. 2017].

[35] Limburg (2012) Gebiedsagenda. [online] available at: http://www.limburg.nl/dsresource?objectid=104efd5e-1926-4d6d-8b6b-c39e18a3355b&type=org [accessed 02 Jan. 2017].

table (see appendix policy documents). The most notable actions found relating to energy transition and transport are:

- The development of a new border crossing business park in 2001 between Heerlen and Aachen called the Avantis European Science and Business Park. Avantis will house the first international bauausstellung (IBA) in the Netherlands. this expo, set in 2020, is used to showcase and kickstart developments in the domain of new energy in the area.
- The proposition for an intercity railing connecting Maastricht to Aachen, running through Heerlen. This train line is dubbed the Avantisline was supposed to run right through the Avantis business park. Unfortunately this plan is receiving insufficient political and financial support and has been postponed ever since 2011.

What kind of urban challenge are we facing in the region?

Based on the previous information the following three choices come to light:

- The choice for a clear interrelated region with the best possibilities for a comprehensive approach.
- The choice for an achievable strategy in transport modes that supports the regional development but is also adaptable and scalable to the continuous change in the region.
- The choice to kickstart progress from a coherent ambition set for the region.

The following chapter will address these choices.

4. Choices in urban development & transport
Decrypting transport, case studies & data

Chapter two and three have led us to the establishment of three choices to be made. In this chapter we will argue these choices by relating urban development and transport. To do this Ebenezer Howard's Garden City methodology will be used. This methodology stretches the relation of a core and its satellite cities through infrastructure. Howard believed that overcrowding of cities was one of the more troubling issues of his time. Howard's garden city concept visualises a region as a polycentric network of satellite towns with a central core.[36] To have the region work together a network of connections by road, rail and water is applied.

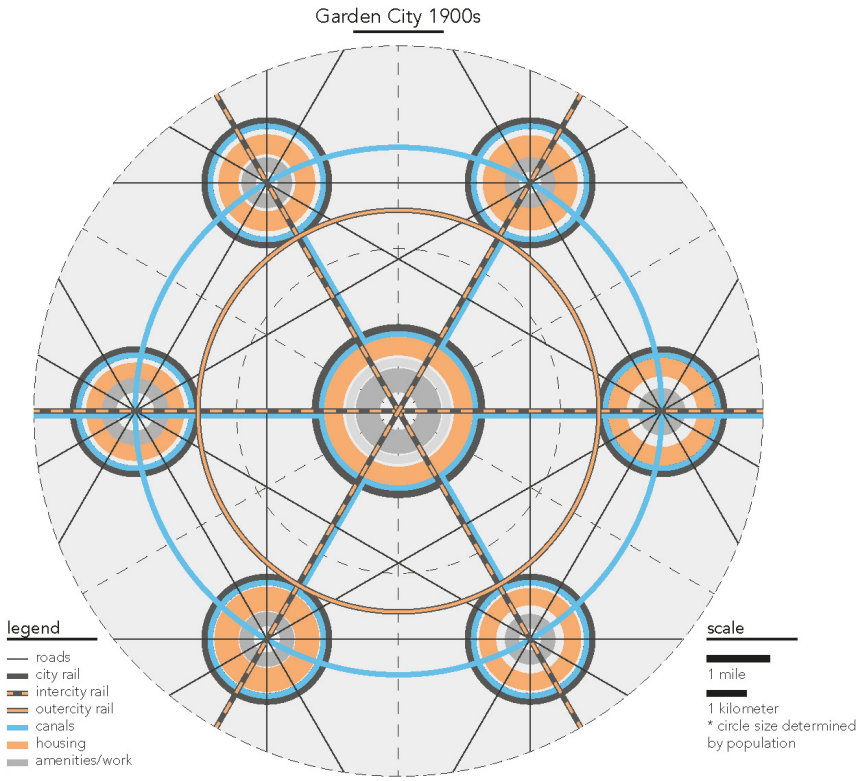


Illustration 8: Ebenezer Howard's Garden City methodology

The choices made have to be in line with the regional agenda. They focus on strengthening the economic profile, intensifying connectivity, capitalising on the quality of life in the region and facilitating a higher level of human capital and labor potential. This chapter chooses an interrelated region, an agile strategy in transport for Parkstad and a way to kickstart progress and bring development on its way.

[36] Howard, E. (1902). Garden Cities of To-morrow (2nd ed.). London: S. Sonnenschein & Co, pp. 2–7

4.1 The choice for a clear interrelated region

In recent years several regions have been defined for the varying purposes. This was done based on multiple governmental and municipal research and strategy documents. Most of the criteria have been set from the administrative domain. In the following model we look at a regional strategy from the perspective of transport. To do this, varying levels levels of scale have to be addressed. Optimisation of transport modes can be approached on a local (0-10km), regional (10-50km) and (inter)national (>50km) level. This research focuses on the regional level and how it relates to a higher national level.

Local

The illustration below shows Howard's Garden city methodology applied to the Parkstad area. In Howard's model the diameter of the circle is determined by population and area matching in an ideal density. This research chose to determine circle diameter by population as this shows total potential ridership. This is important in comparing the importance of set connections. Current rail lines direct to Sittard (Nuth), Maastricht (Voerendaal) and Aachen (Landgraaf). These lines originate from earlier lines of train connections. There are two high speed ways for cars running from north to south. Heerlen is the core city to the Parkstad region.

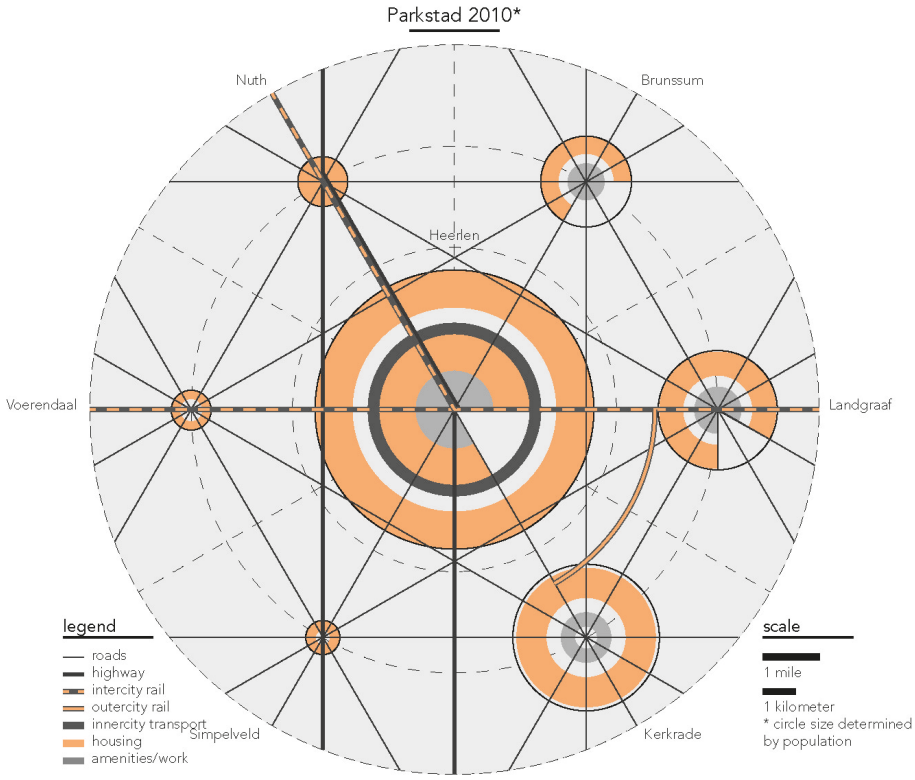


Illustration 9: Garden City methodology applied to Parkstad

International

This model shows Parkstad within the largest scale network. That of airports and high speed rail connections. Only the main stops of the high speed rail line are shown here. Parkstad is not connected to this level of transport. It is 50km away from Liège, which is connected.

Illustration 10: Parkstad in high speed rail and aviation network

Regional

This model shows Parkstad and the proximity of other city regions. The circle diameter is determined by population. The high speed rail has stops in Liège and Aachen. The two planes represent Liège airport and Maastricht-Aachen airport. The four cities are all connected by highway and rail. They also lie at the centre of a region dubbed the Meuse-Rhine Euroregion. This region is shaped around the cities Hasselt, Maastricht, Heerlen, Aachen, Eupen and Liège.

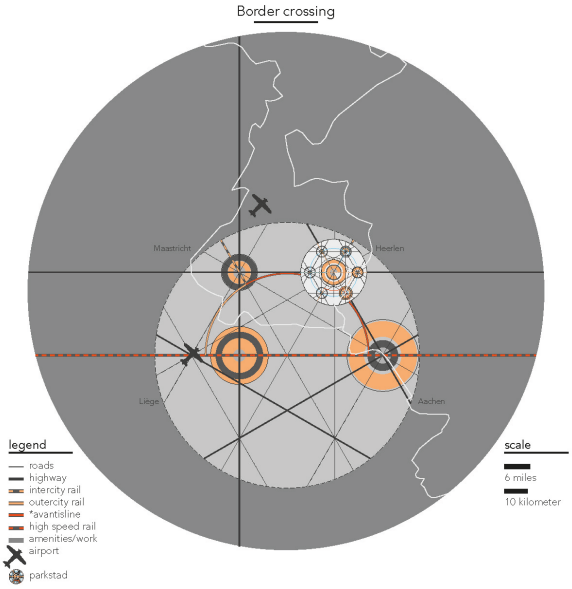


Illustration 11: Parkstad related to nearby major urban areas

A clear interrelated region

Although Heerlen is the core city of the Parkstad region, it is not part of the highest international level of transport. Heerlen, Maastricht, Liège and Aachen form a network of cities based on their close proximity. The following model shows the relation of the core cities in the Meuse-Rhine Euroregion. Eupen is considered a satellite town to either Aachen or Liège due to it's population of 19,000. Hasselt is placed outside the diagram circle due to its distance from the centre.

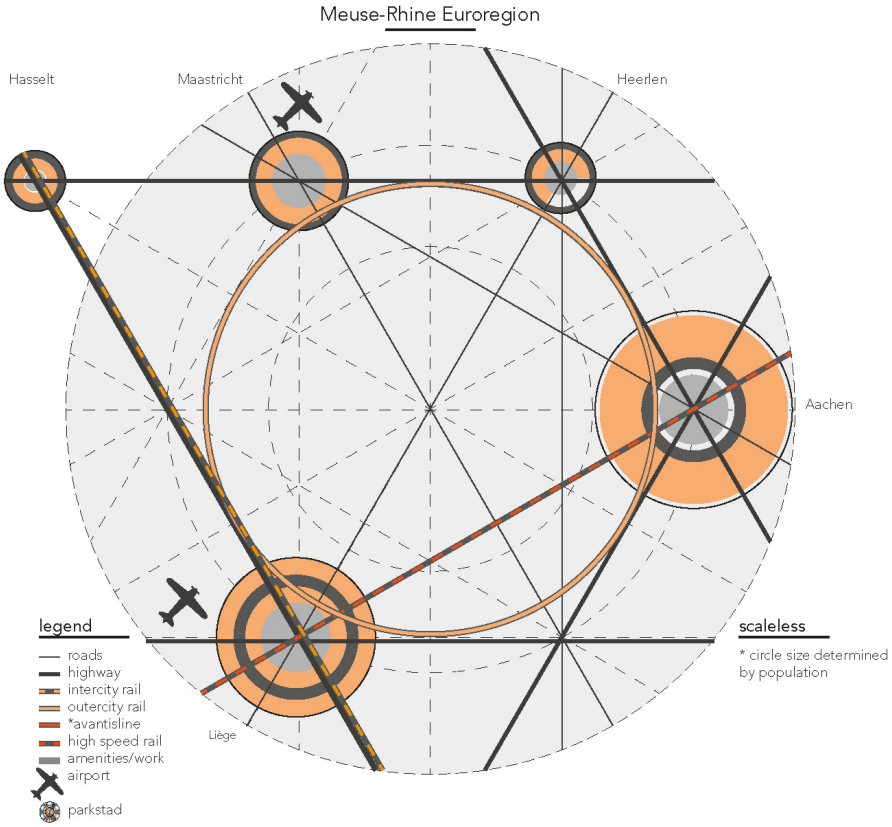


Illustration 12: Garden city methodology applied to Meuse-Rhine Euroregion

On this scale Heerlen is one of the smaller regions when considering population. However when looking at Parkstad it equals the size of Aachen. The scales of interest are the relation of Parkstad to Heerlen and that of Heerlen to the major cities. To capitalise on the quality of life in the region, Parkstad is to acknowledge the value of its proportions of urban and nature; garden cities. Through intensifying the connection of Parkstad to other core cities a higher level of human capital is attracted and the economic profile will strengthen.[37] The key to improving Heerlen and the Parkstad region is to improve the connection with the Meuse-Rhine Euroregion.

[37] Limburg (2012) Gebiedsagenda. [online] available at: http://www.limburg.nl/dsresource?objectid=104efd5e-1926-4d6d-8b6b-c39e18a3355b&type=org [accessed 02 Jan. 2017].

4.2 The choice for an agile strategy in transport

The most important choice for a successful development of the region is that of the connection of the four core cities. One of the proposals currently attempted is the development of the Avantisline from Maastricht to Aachen. This rail line is set to connect Maastricht to Aachen through Heerlen. The following model shows key elements from the policy documents for this region and the

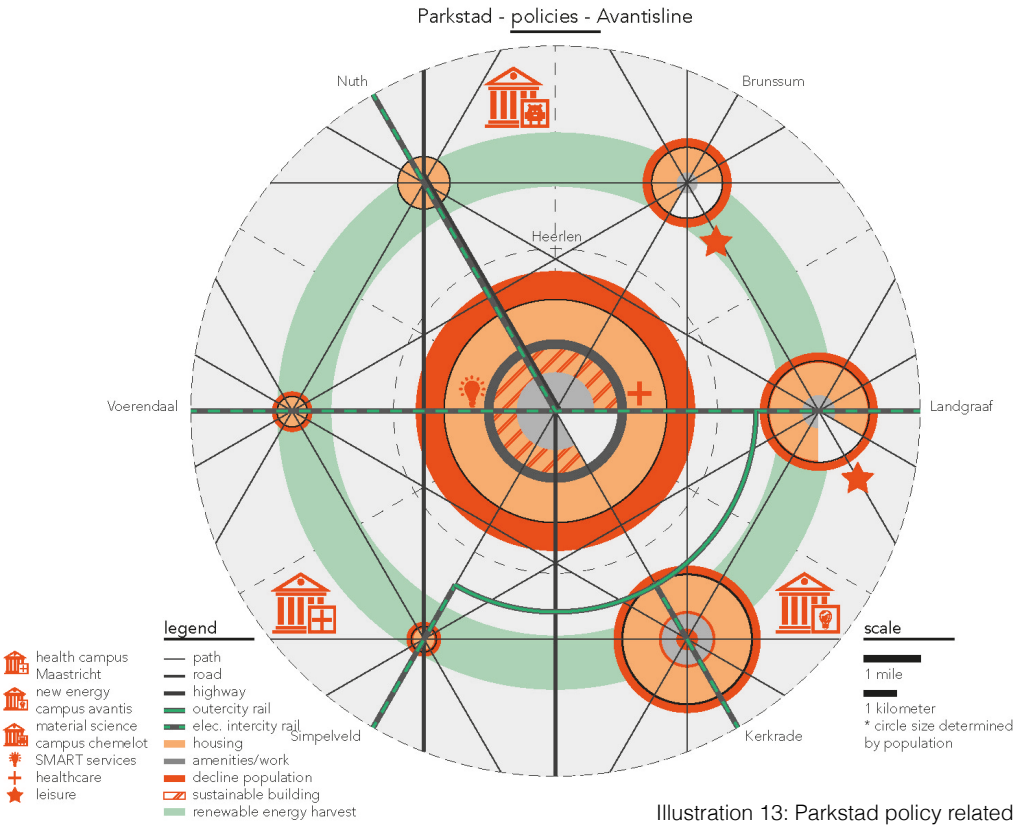


Illustration 13: Parkstad policy related to Avantisline

new lines of connection when the Avantis line is finished. It is estimated that following the realisation of the Avantisline the decline of population in Kerkrade, Landgraaf will become less. The Avantisline has been planned but postponed ever since 2011. The costs are simply too high. This is mostly due to the heavy infrastructure needed to double and electrify the tracks between Heerlen and Aachen.

Considering the ongoing revolution in transport from fossil fuels to renewable energy, I would suggest a different approach. A strategy including a mode of transport of a more agile character. One that has less infrastructural impact and less investment costs. This mode anticipates a revolution in our transport and acknowledges a new way of transit, one better suited for this network of four cities, will develop in the next 25 years. This strategy acknowledges that the revolution requires a more clear and hierarchical division through the scales of transport. The map on the next page shows the current connection of Heerlen to Aachen and all the stops in between. Dark orange represents

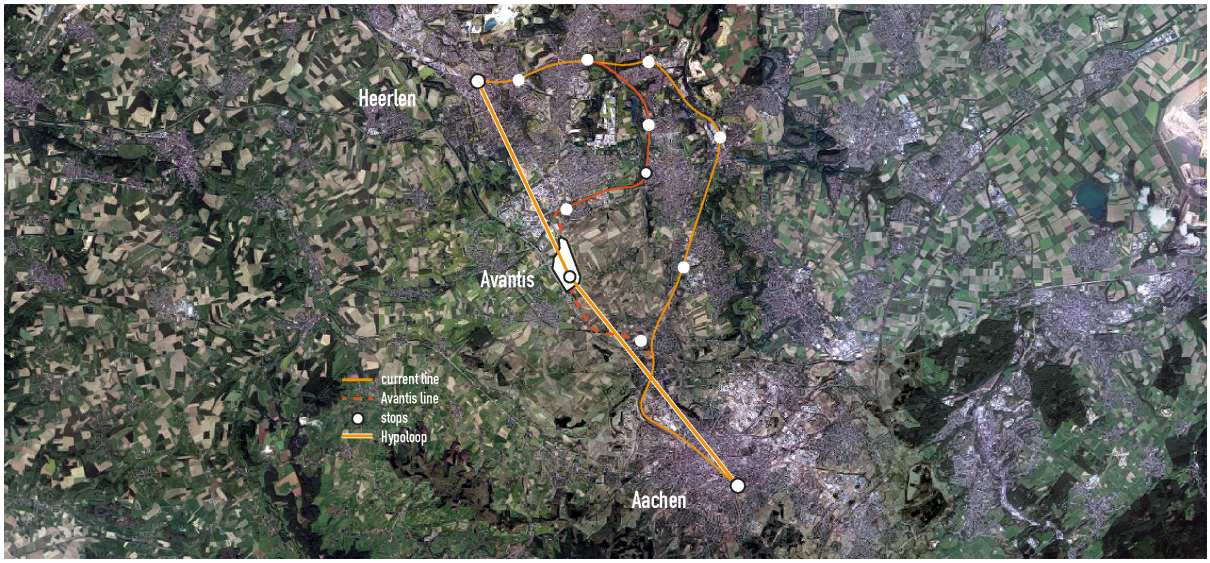


Illustration 14: Current rail line, Avantisline and proposed connection Heerlen-Aachen

the Avantisline meant to replace the current line. The third line is my proposal for a straight line, connecting core cities Heerlen and Aachen. Crossing the prospected economic centre of the Avantis business park on the border of Germany and The Netherlands. This line is one of four major lines connecting two of the four core cities in the Meuse-Rhine Euroregion. When this strategy is implemented the hierarchy of Parkstad will also reshape accordingly. The Parkstad region will have personalised transport. This is either the bicycle or the car. The car is offered in rental and taxiing

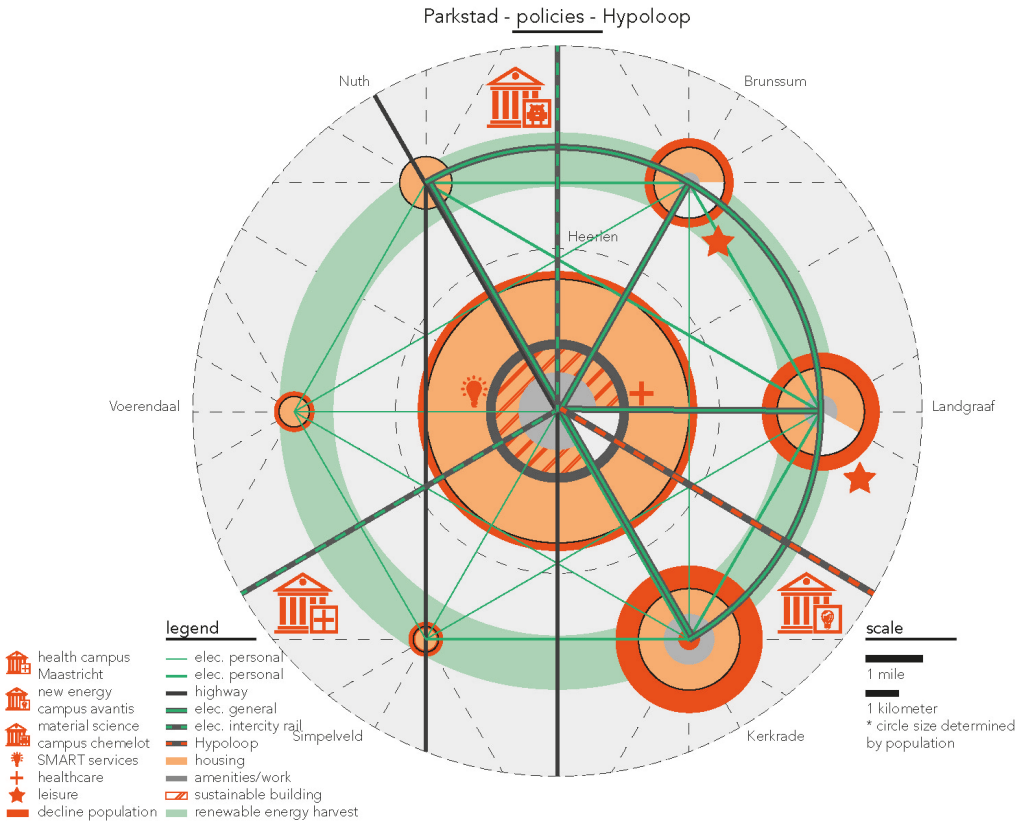


Illustration 15: Parkstad policies related to proposed new Hypoloop

services and should be encouraged over the possession of transport. When satellite cities have enough population to facilitate a certain occupancy rate general transport is applied. To better guarantee travel times and keep investment costs low this general transport should make use of existing infrastructure on dedicated lines i.e. a car lane only to be used by electric shuttle busses. All lines connect to Heerlen as this is the quickest way to get to one of the other four major centres.

4.3 The choice to kick-start progress

Concluding this research the question how the energy transition in mobility can serve policy initiatives addressing the decline of population in Parkstad can be answered with the following challenge.

Develop a mode of transport to improve the connection of the four core cities in the Meuse-Rhine region. This transport should facilitate the Parkstad region in its four key ambitions: (1) the strengthening of the economic profile; (2) intensifying connectivity; (3) capitalising on the quality of life in the region; and (4) facilitating a higher level of human capital and labor potential. This is done through connecting Heerlen to Aachen and positioning Parkstad in a clear hierarchical plan of transport ranging from local to international scale. The development anticipates a revolution in our transport and acknowledges a mode better suiting the network of these four cities will develop in the next 25 years. Therefor less infrastructural impact and less investment costs are demanded. The regional scale needs a mode of transport similar to some of the characteristics of the Hyperloop.

With this paper I propose a concept for a sixth mode of transport, the Hypoloop. A hypothetical mode of transportation with the following conditions: immunity to weather, collision free, minimal infrastructure, speed ranging from 30 to 60km/h, electric powered, low power consumption, energy storage for 24-hour operations, and flexible in infrastructure to adjust to developing transport demands. One that carries small groups, is adaptable in capacity and infrastructure, has a low energy use, has low investment costs and a low period of return on investment. The transport is meant to attract and connect people to rail transport and provide relief from roads and car travel. Travel by pods is estimated at carrying 10 to 20 people leaving every .5/5 minutes. Pod size and frequency is to be determined by the connected area's population and level of ridership.

This mode of transport should be used for the IBA in 2020, as inadequate transport will have great impact on the success of the planned Expo and further developments in the area of new energy. The transport needs a stop on the Avantis business park for this and future purposes.

5. Conclusions
Transport, decline & action

The Netherlands are dealing with a decline in population and a set back in the energy transition. Both challenges are related to transport. The goal of working on mobility and accessibility is improving international connections, stimulating and facilitating the economic structure, growing employment and improving the liveability and attractiveness of a region. Transport is one of the key aspects to our settlement patterns.

5.1 Past & future of transport

It is never just technological innovation that sets a transport revolution in motion. It is a combination of circumstances in multiple domains such as the political, economic and social. Therefore a comprehensive approach is needed. Governmental policies can be a prime instigator in developments. The government is also prime player in Dutch urban development. This opens up new changes and responsibilities. Changes in transport can move quickly and disruptive. Urban planning sometimes remains decades after its realisation. Anticipation for the next transport revolution therefore is an absolute must for parties involved in the establishment of our long term built environment.

When regarding transport for urban planning there are three major oppositions that have to be accounted for: local vs. global, brief vs. enduring and personal vs. general. These need to be balanced both individually and together. Urban planners have to take in account the possibility of future changes in transport. There is a necessity for flexibility and anticipation towards change.

The energy transition is unavoidable. When regarding transport it is also evident to happen in the period up to 2040. It is necessary to anticipate for this revolution in our urban planning. The transition that lies ahead is that of changing from conventional towards renewable energy. On one hand we keep developing technology for conventional modes of transport to make them more fuel efficient. On the other we electrify all conventional modes of transport that we currently know. A third step needed is to develop new modes of transport. Modes that are built for renewable energy and consider our total usage of energy for transport. In the transition to electricity, our modes of transport need adjustments in scale and efficiency. New modes need to be developed on international level as an alternative to aviation and on a regional level as an alternative to the car, bus and metro.

5.2 Demographics & policies

The Netherlands currently know 20 regions that are, or soon will be, dealing with a decline in population. The municipalities of Zeeuws-Vlaanderen, South-Limburg and North- & East-Groningen are estimated to lose 16% of their population by 2040. The average Dutch region will have grown in population by 11% in that same time.

The region of South-Limburg is unique from other declining areas in the Netherlands in that the amount of jobs reachable in an hour is equal to the Randstad. Its population is also ageing. Parkstad is a joint effort of a number of municipalities in South-Limburg to create a strategy that better addresses the changing situation in the region. What seems strange is that regions nearby Parkstad crossing over to Germany and Belgium come from a similar history of mining yet they continue to grow in population.

With regard to the effect of transport on urban development three major choices need to be made. The choice for a clear interrelated region with the best possibilities for a comprehensive approach. The choice for an achievable strategy in transport modes that supports the regional development but is also adaptable and scalable to the continuous change in the region. The choice on how to kickstart this progress from a coherent ambition set for the region.

5.3 Choices in urban development

When we answer the three choices concerning transport in urban development the following challenge is formulated. Develop a mode of transport to improve the connection of the four core cities in the Meuse-Rhine region. This mode of transport should facilitate the Parkstad region in its four key ambitions: (1) the strengthening of the economic profile; (2) intensifying connectivity; (3) capitalising on the quality of life in the region; and (4) facilitating a higher level of human capital and labor potential. This is done through connecting Heerlen to Aachen and positioning Parkstad in a clear hierarchical plan of transport ranging from local to international scale. The development anticipates a revolution in our way of transport and acknowledges a mode better suited for the network of four cities which will develop in the next 25 years. Therefor less infrastructural impact and less investment costs are demanded. The regional scale needs a mode of transport similar to some of the characteristics of the Hyperloop.

This paper proposes a concept for a sixth mode of transport, the Hypoloop. A hypothetical mode of transportation with the following conditions: immunity to weather, collision free, minimal infrastructure, speed ranging from 30 to 60km/h, electric powered, low power consumption, energy

storage for 24-hour operations, and flexible in infrastructure to adjust to developing transport demands. One that carries small groups, is adaptable in capacity and infrastructure, has a low energy use, has low investment costs and a low period of return on investment. The transport is meant to attract and connect people to rail transport and provide relief from roads and car travel. Travel by pods is estimated at carrying 10 to 20 people leaving every .5/5 minutes. Pod size and frequency is later determined by the connected area's population and level of ridership.

This mode of transport should be used for the IBA in 2020, as inadequate transport will have great impact on the success of the Expo and further developments in the area of new energy. The transport needs a stop on the Avantis business park for this and future purposes.

6. Research limitations
Limitations, relevance & future research

In writing this research a number of general findings have come to light. This chapter discusses the limitations, relevance and possible continuing of this research.

6.1 Limitations

It is understood the sixth mode of transport described cannot be easily created in this short amount of time. In order to realise the proposed transport strategy before the Expo in 2020 we will have to look at our existing options. What mode of transport most resembles the definition that is given. How can the investments made now also be used for this future mode of transport? This paper acknowledges the need to go deeper into modes of transport that are currently existing and being developed. It does not go into detail how this mode of transport physically influences its context en built environment. This will be examined in the research and design of the related graduation project.

6.2 Relevance

In the Netherlands alone 20 regions are or will be facing decline. Zeeland and Groningen have unique situations to address. Declining regions and the move towards the city can be found across the globe. The energy transition concerns everyone.

6.3 Future research

The garden city methodology and current case of Parkstad are interrelated. The body of knowledge and method of analysis can be taken to other urban areas. America has been dealing with large numbers of decline in cities ever since the 1950's. Urban sprawl and the consuming of materials and energy there is greater than in Europe. A personal interest and possible future research would be to apply the Hyper- and Hypoloop concepts to metropolitan areas like that of Chicago or Detroit.

Appendices

Interview questions, participant letters/forms, surveys, supplemental tables/figures/graphs/image

List of policy documents:

Actualisatie regionaal verkeer- en vervoersplan 2011-2020

Working towards a sustainably robust region (2012)

Programmaplan railinfrastructuur, spoor- en busvervoer (2013)

Begroting 2017 en Meerjarenraming 2018-2020

Avantis: stedenbouwkundige strategie 2012-2022

Brochure light rail op de kaart 2040

Gebiedsagenda Limburg (2012)

Cross-borders; necessity of transboundary cooperation (2016)

Monitor Brainport Network (2016)

Parkstad Limburg; bevolkingsprognose en prognose woningvoorraadbehoefte 2008-2040

Ontwerp intergemeentelijke structuurvisie parkstad Limburg; ruimte voor park en stad (2009)

quick scan Avantislijn (2009)

Structuurvisie Heerlen 2035

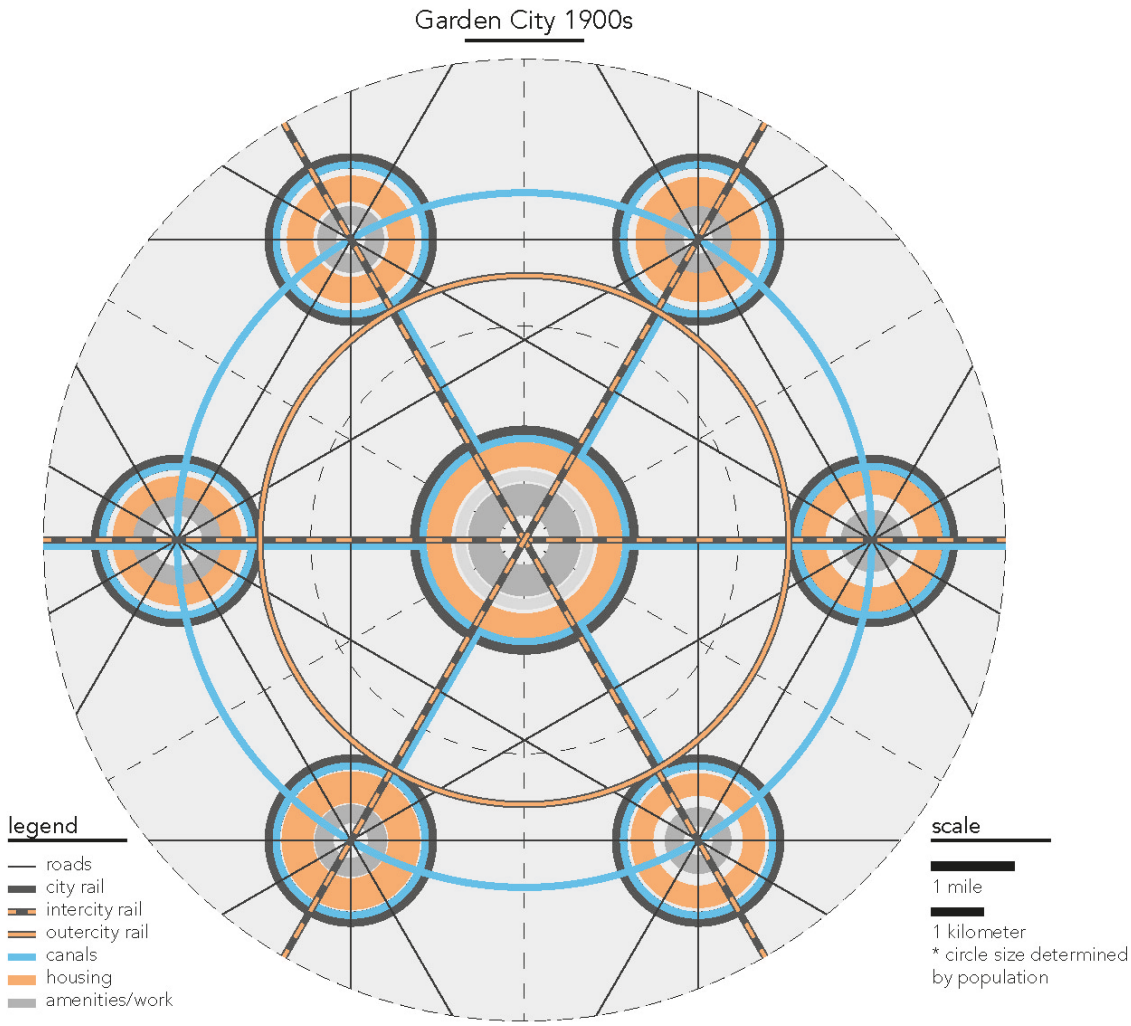
Natuurtoets bestemmingsplanherziening Avantis GOB (2012)

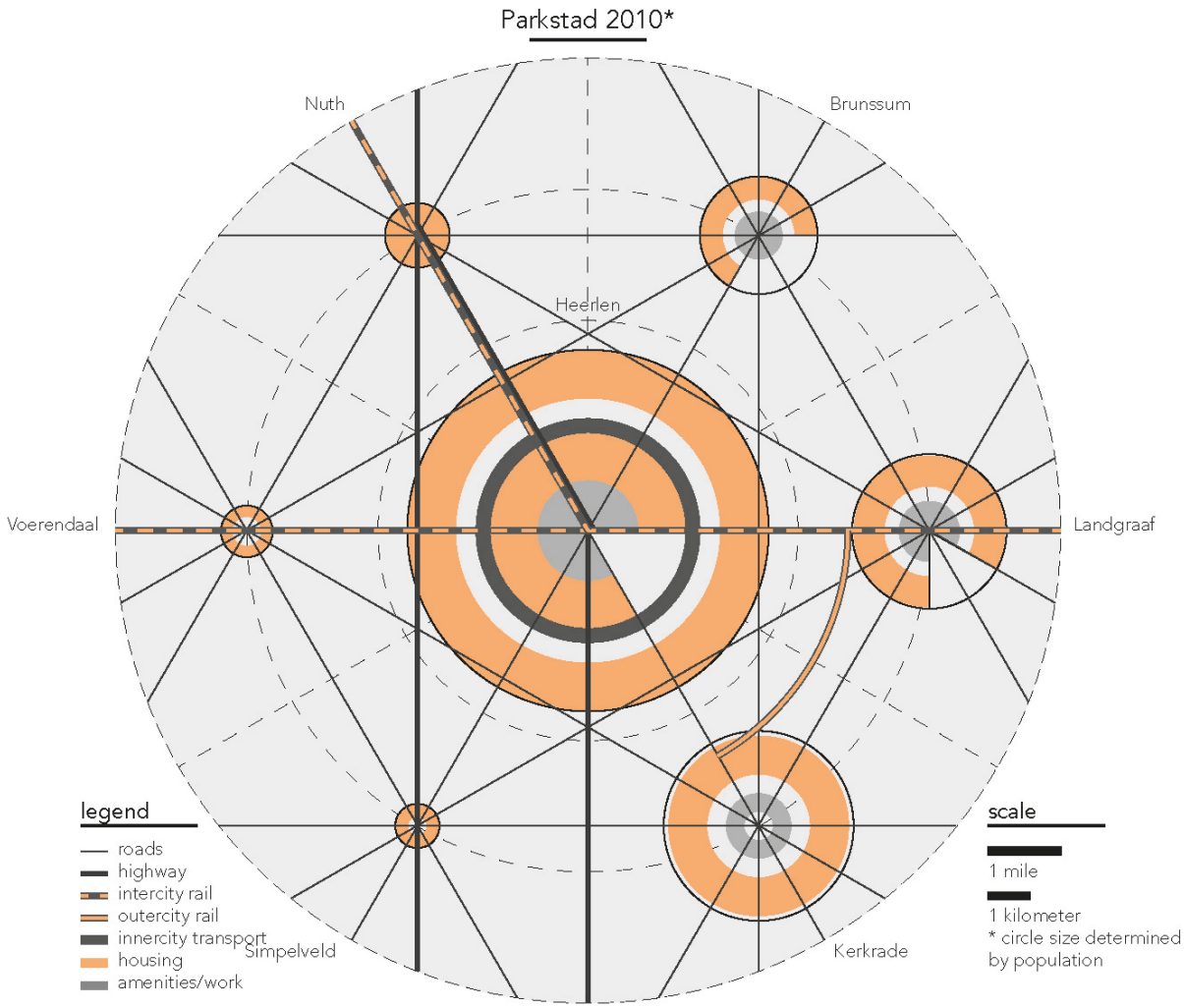
Trendrapport Limburg (2015)

Zuid Limburg Science Campus (2010)

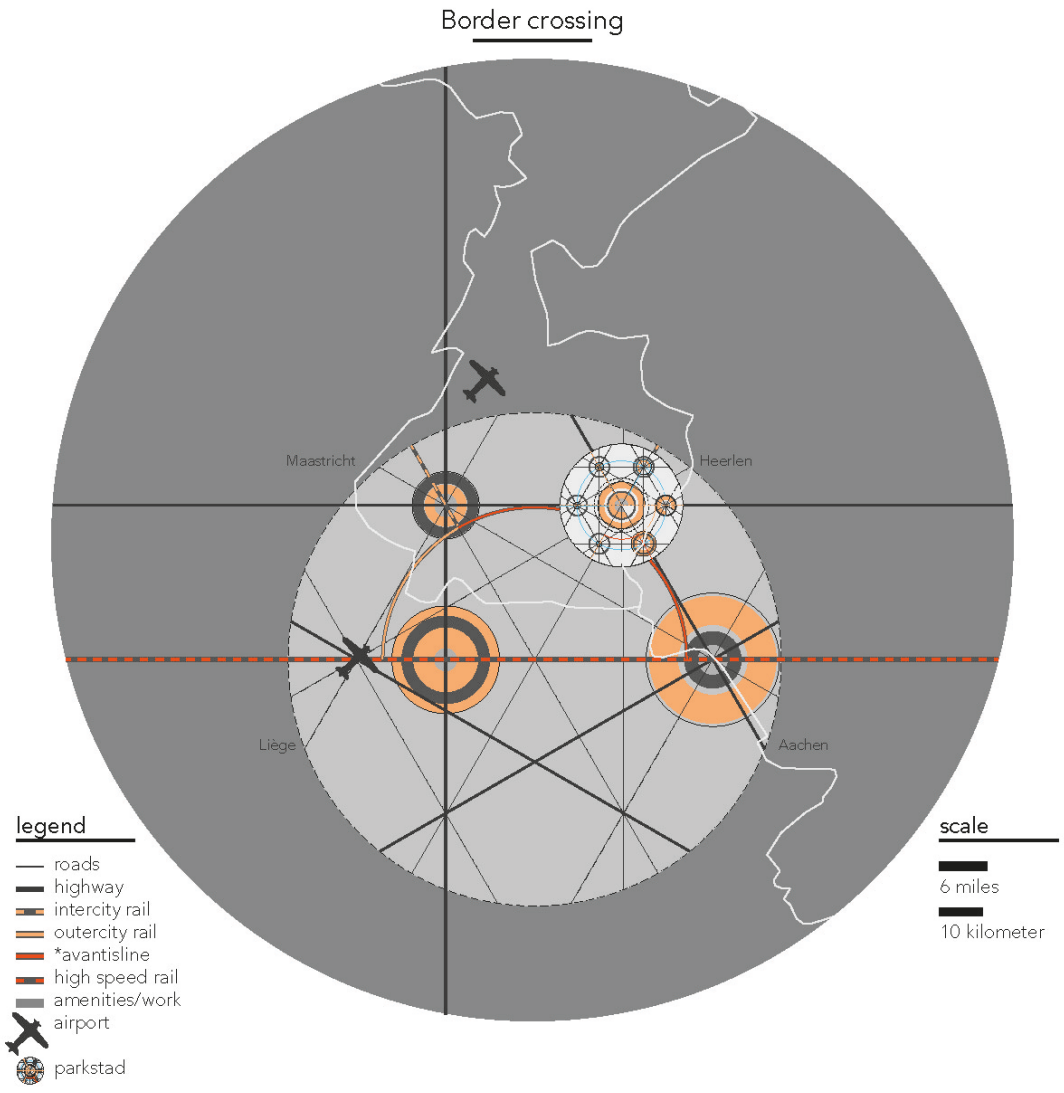
Energietrends 2016

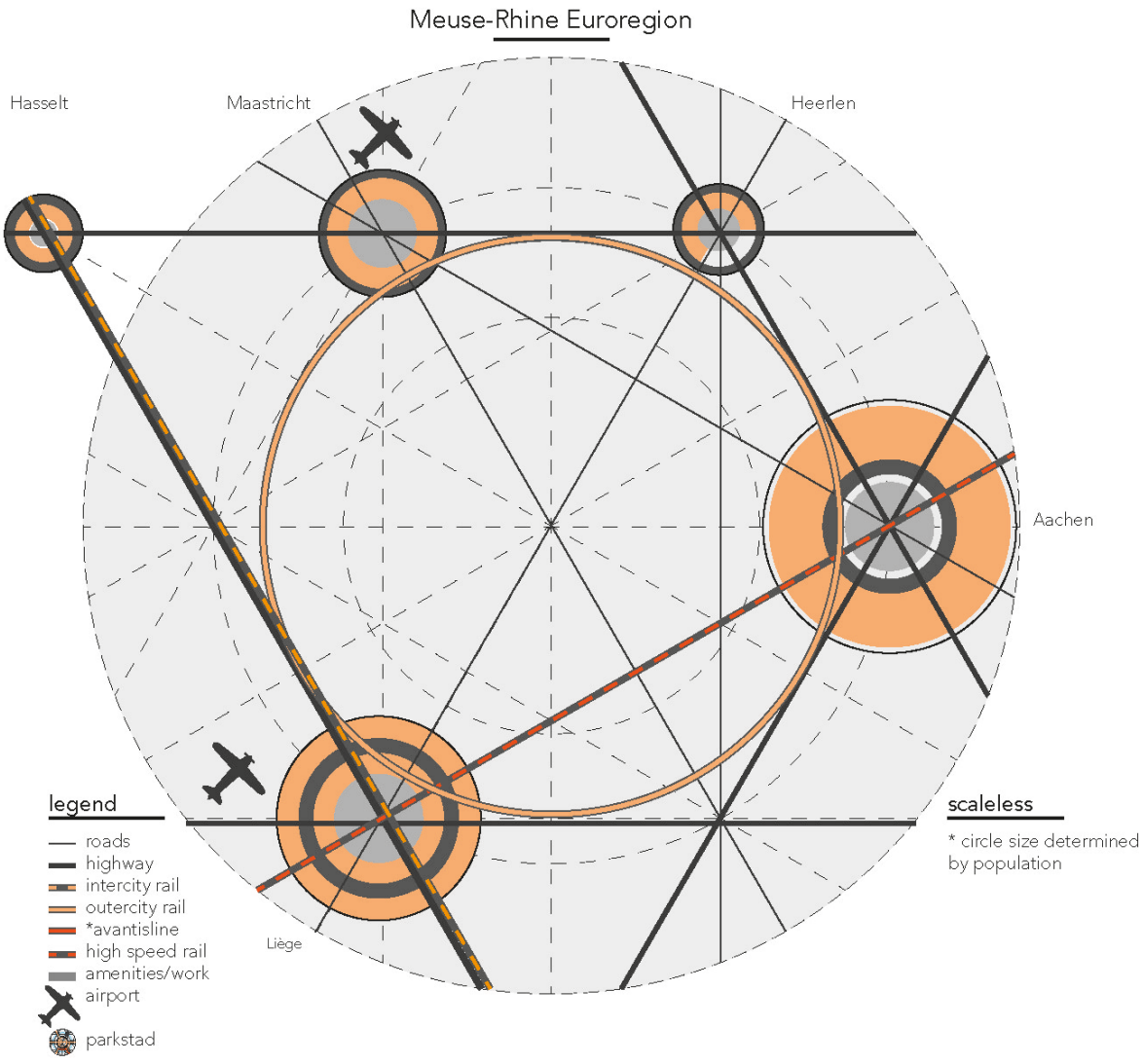
Bevolkings- en huishoudensprognose privincie limburg 2015-2050


Garden City 1900s
legend
roads
city rail
intercity rail
outercity rail
canals
housing
amenities/work
scale
1 mile
1 kilometer
* circle size determined by population


Parkstad 2010*
Nuth
Brunssum
Heerlen
Voerendaal
Landgraaf
Simpelveld
Kerkrade
legend
roads
highway
intercity rail
outercity rail
innercity transport
housing
amenities/work
scale
1 mile
1 kilometer
* circle size determined by population


Europe
Amsterdam
Schiphol
Rotterdam
Antwerp
Brussels
Liège
Hannover
Essen
Duisberg
Köln
Fulda
Frankfurt airport
Frankfurt
Luxembourg
Mannheim
legend
airport
high speed rail
main stop
parkstad
economic regions
scale
30 miles
50 kilometer


Border crossing
Maastricht
Heerlen
Liège
Aachen
legend
roads
highway
intercity rail
outercity rail
*avantisline
high speed rail
amenities/work
airport
parkstad
scale
6 miles
10 kilometer


Meuse-Rhine Euroregion
Hasselt
Maastricht
Heerlen
Aachen
Liège
legend
roads
highway
intercity rail
outercity rail
*avantisline
high speed rail
amenities/work
airport
parkstad
scaleless
* circle size determined by population

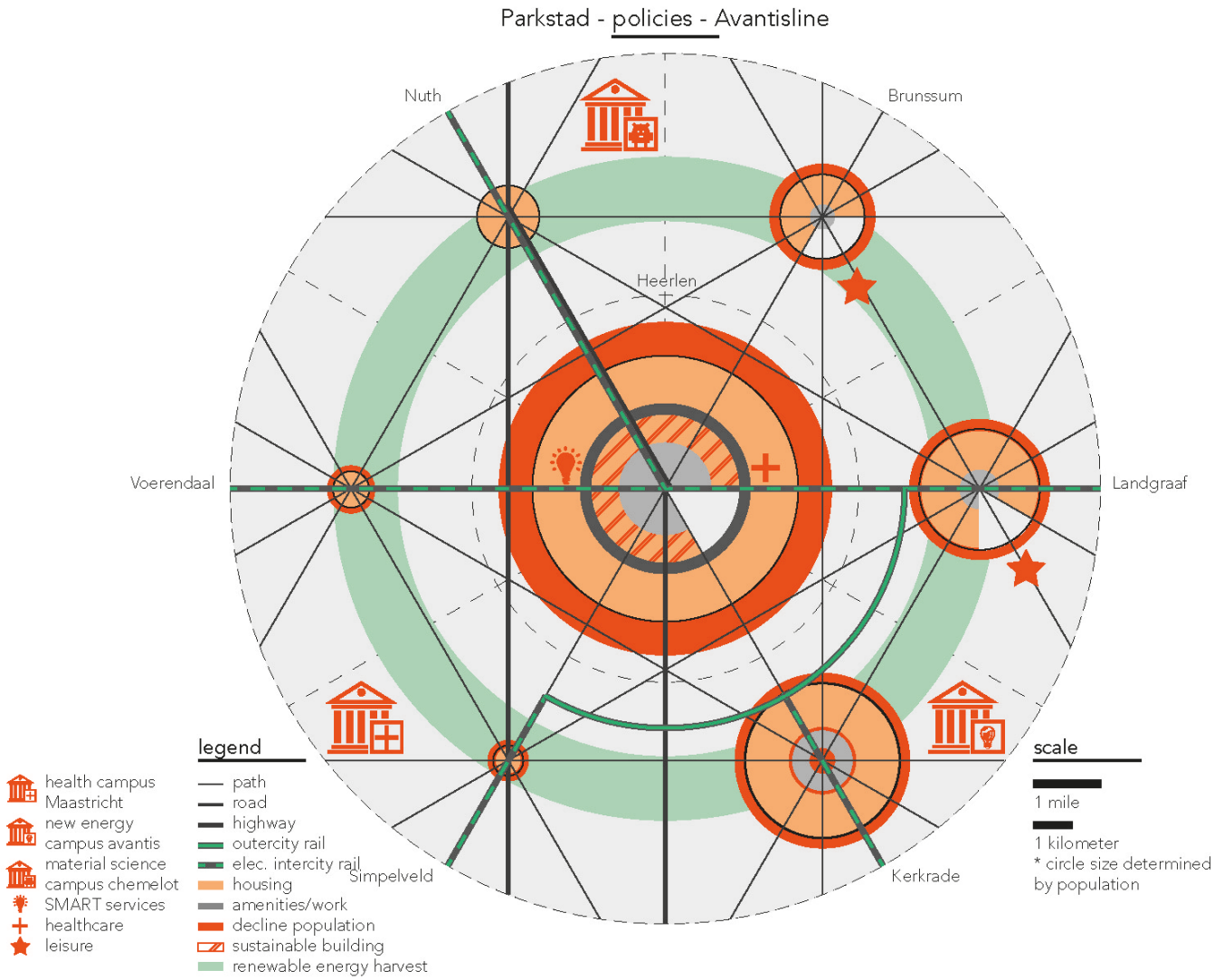
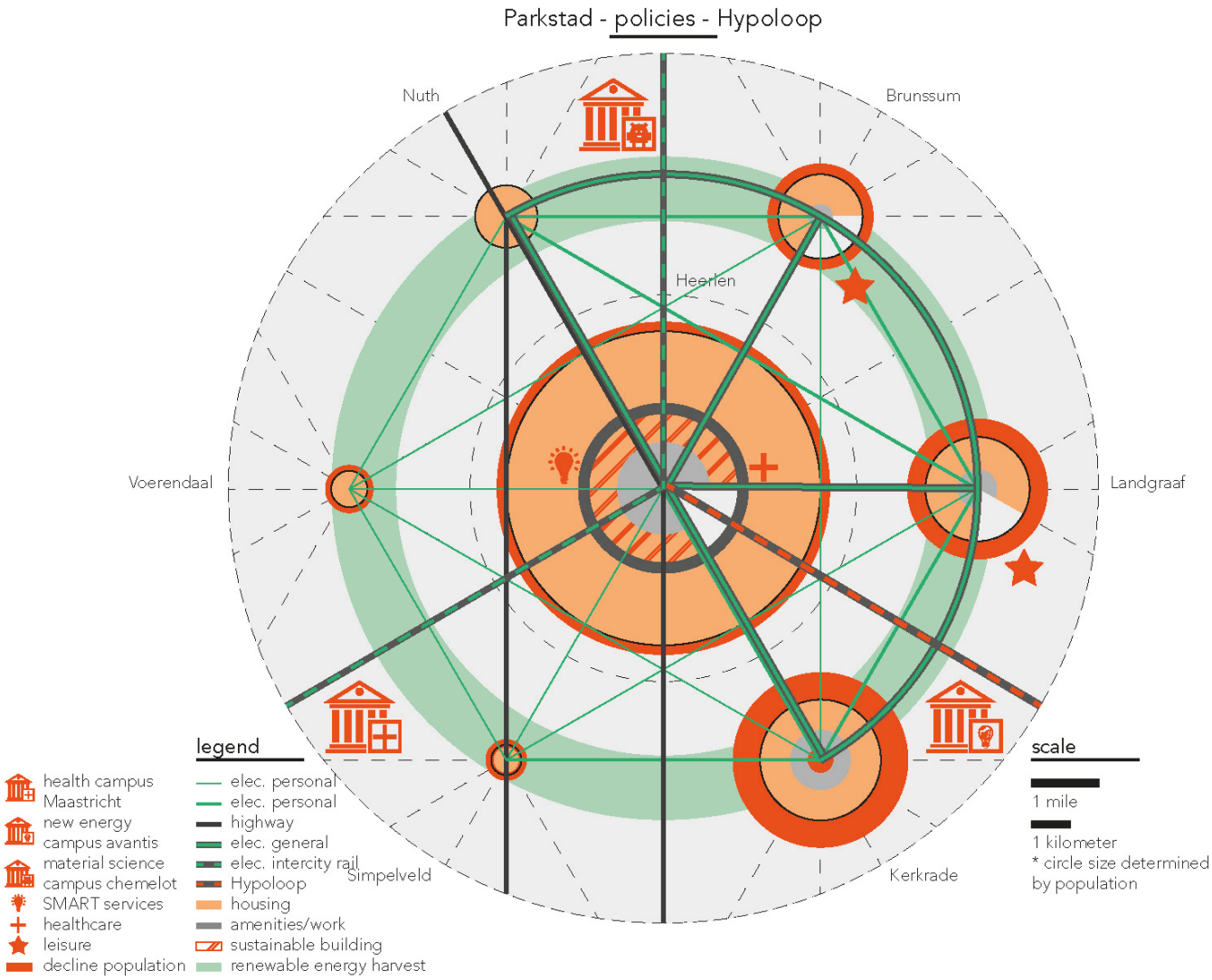

Parkstad - policies - Avantisline
Nuth
Brunssum
Heerlen
Voerendaal
Landgraaf
Simpelveld
Kerkrade
legend
health campus Maastricht
new energy campus avantis
material science campus chemelot
SMART services
healthcare
leisure
path
road
highway
outercity rail
elec. intercity rail
housing
amenities/work
decline population
sustainable building
renewable energy harvest
scale
1 mile
1 kilometer
* circle size determined by population

Illustration 14: Current rail line, Avantisline and proposed connection Heerlen-Aachen page 29


Parkstad - policies - Hypoloop
Nuth
Brunssum
Heerlen
Voerendaal
Landgraaf
Simpelveld
Kerkrade
legend
health campus Maastricht
new energy campus avantis
material science campus chemelot
SMART services
healthcare
leisure
decline population
elec. personal
elec. personal
highway
elec. general
elec. intercity rail
Hypoloop
housing
amenities/work
sustainable building
renewable energy harvest
scale
1 mile
1 kilometer
* circle size determined by population

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Illustrations

Illustration 1: Kamphuis, W.A.P. (2016). Table showing modes of transport and energy they run on

Illustration 2: Kamphuis, W.A.P. (2016). Table showing four strategies related to the energy transition

Illustration 3: PBL & CBS (2014). Nederlandse bevolking trends en keerpunten. [online] available at: http://www.pbl.nl/infographic/nederlandse-bevolking-trends-en-keerpunten [accessed 02 Jan. 2017].

Illustration 4: CBS (2015). Aandeel jongeren tot 30 jaar, aandeel 65 plussers. [online] available at: https://www.werk.nl/werk_nl/arbeidsmarktinformatie/achtergrond/daling-werkgelegenheid-bevolkingsafname [accessed 02 Jan. 2017].

Illustration 5: Atlas voor Gemeenten (2015). aantal banen bereikbaar in een uur, nationaal en over de grens. [online] available at: https://www.zuidlimburg.nl/modules/zuidlimburg/newsletterarchive/archive.php?id=86 [accessed 02 Jan. 2017].

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Illustration 7: EIS (2016). Bevolkingsontwikkeling deelgebieden Euregio Maas-Rijn. Euregio Maas-Rijn in cijfers, p.19 [online] available at: http://forum.mestreechonline.nl/forum/mestreech-maastricht/maastricht-2025-grote-projecten/1880-krimp-nu-is-het-afgelopen [accessed 02 Jan. 2017].

Illustration 8: Kamphuis, W.A.P. (2016). Ebenezer Howard's Garden City model

Illustration 9: Kamphuis, W.A.P. (2016). Garden City model applied to current Parkstad

Illustration 10: Kamphuis, W.A.P. (2016). Parkstad in high speed rail and aviation network

Illustration 11: Kamphuis, W.A.P. (2016). Parkstad related to nearby major urban areas

Illustration 12: Kamphuis, W.A.P. (2016). Garden city model applied to Meuse-Rhine Euroregion

Illustration 13: Kamphuis, W.A.P. (2016). Parkstad policy related to Avantisline

Illustration 14: Kamphuis, W.A.P. (2016). Current rail line, Avantisline and proposed connection Heerlen-Aachen

Illustration 15: Kamphuis, W.A.P. (2016). Garden city model applied to Meuse-Rhine Euroregion