

ECO CITY, ECO TRANSPORT

-- URBAN REDEVELOPMENT IN ARNHEM CENTRAL SOUTH

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Urban regeneration

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COLOPHON

Eco city, eco transport
-- Urban redevelopment in Arnhem central south
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Part 1 Introduction

1.1. Motivation

'The future of petroleum is that it has no future.'
(Black, 2010, p.45)

Coal, oil and natural gas are called fossil fuels. It is the main energy source from industry revolution onwards. However, based on Hubbert's peak oil theory (Figure 1.1), the Oil Age may come to an end for a shortage of oil. It predicts that oil production will soon start a terminal decline. Oil has unique physical properties that make rapid substitution difficult, which means the price may be determined largely by supply capacity (IMF, 2011).

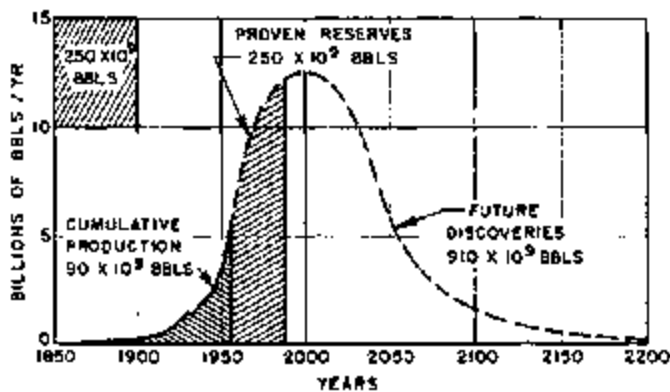


Figure 1.1 Ultimate world crude-oil production based upon initial reserves of 1250 billion barrels. (Hubbert, 1956)

In contrast, if more abundant natural or synthetic resources can eventually replace oil in the production process, then relatively small increases in prices may redirect demand toward these substitutes (IMF, 2011). The 'techno-optimists' declare that the oil scarcity would not only lead to higher oil prices but would also trigger a transition to alternate energy sources, such as renewable energy or a new generation of improved nuclear reactors (Smil, 2008).

From a technical viewpoint, the dependency of industrial society on any specific primary energy source: such as oil, could be reduced by relying more on electricity. In theory, this has the potential of mitigating the impact of peak oil and postponing the decline of overall world energy consumption. However, the low price elasticity of oil indicates that this would require consider-

able investment over a sustained period of time. That is, while it is a formidable task to convert the existing vehicle fleet to electricity, the generic dependency of industrial society on fossil fuels for electricity production would be stagnant (Friedrichs, 2012). Friedrichs argues that, 'in the event of peak oil, we should not expect either immediate collapse or a smooth transition. People do not give up their lifestyle easily. We should expect painful adaptation processes that may last for a century or more.' (Friedrichs, 2012, p.67)

One of the many daily routines people would not change easily is their travel behaviours, the transportation, which highly depends on oil production. Diesel fuel, propane, jet fuel, gasoline, or reformulated gasoline, the source of all these fuels comes from crude oil, and they are our primary energy source for transportation. Black (2010) predicts we would run out of petroleum by the year 2038, if the reserves don't increase, the consumption grows at the current growth rate for energy consumption. 'The continued use of petroleum-based fuels for our transport system is therefore not sustainable.' (Black, 2010, p.46)

The use of fossil fuels on transportation is also responsible for environmental problems, climate change and urban air quality. It is known that the green gas is the reason for global warming, and the greenhouse gas includes carbon dioxide, methane and nitrogen oxides. They are released whenever we burn fossil fuels (coal, natural gas, petroleum) to produce energy. Besides the green house gases, there are other danger gases are produced when the fossil fuels are burned. Carbon monoxide, sulfur dioxide, lead, nitrogen dioxide, ozone, and particulate matter of less than 10 microns in size, these six pollutants are often referred to as the "criteria pollutants" in air quality standards, and they are contained in fossil fuels and are produced when the fuels are burned (Black, 2010). 'Virtually all motorized transport movements are fossil powered...Transport accounts for 22 per cent of total fuel-combustion derived car-

bon dioxide equivalent emissions. Of transport equivalent emissions. Of transport emissions, road movements account for 74 per cent of the total share... of all lead emissions, 90 per cent are transport generated.' (Droege, 2006, p.132) Since gasoline is derived from petroleum, transportation is a significant source of these gases and definitely the main cause of all these problems.

Petroleum, the main source of transportation, is a finite resource with obvious limits to its long-term use (Figure 1.2). Global warming and problems with local air quality are attributable in a large part to the consumption of gasoline by the world's motor vehicle fleet. These suggest that the transportation based on fossil fuels is not suitable for sustainable development. It might be best to consider the development and use of alternative fuels that are renewable and, ideally, do not contribute to both global and local environmental problems.

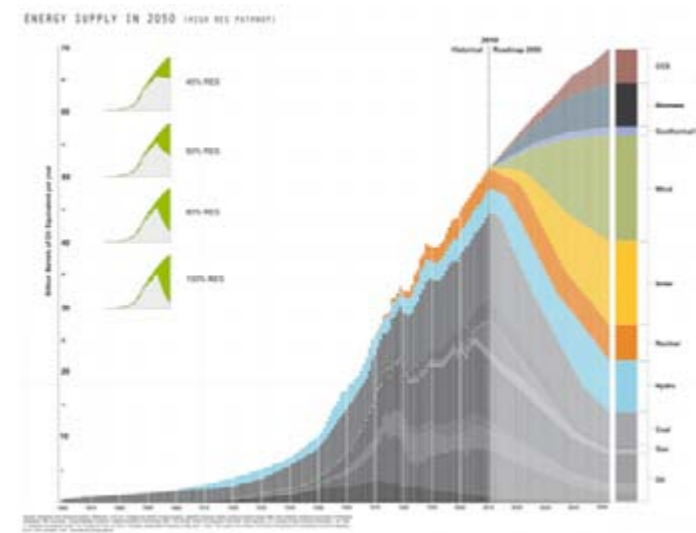


Figure 1.2 Predicted energy supply in 2050 (Infranetlab, 2010)

In general, the direct reaction towards these threatens is searching for the alternate energy sources, such as solar, wind or geothermal energy. Besides that, there is another voice: simply replacing the fossil fuel by renewable energy to cope the crisis and to be sustainable will not solve all the problems, especially traffic congestion and urban sprawl, those negative impacts of fossil-fuelled consumer society. (Droege, 2006)

1.2. Problem statement

The negative impacts of auto dependency have attracted public attentions for years. Ample research demonstrates the impacts of increased auto dependency and air pollution on environmental and health concerns such as; respiratory illnesses, cardiovascular disease, climate change and ecosystem damage. Public health researchers are also examining the relationship of transit choice and wider public health concerns, including stress, physical inactivity, obesity and quality of life.

Fossil fuels free is not equal to sustainable, although we could replace fossil fuel with renewable energy, it does not mean that all the problems that are caused by car-oriented urban form would be resolved. Private cars still consume more energy and space than other transport modes, with or without fossil fuel. Figure 1.3, which shows the energy requirements of a number of common passenger-transport, suggests public transport and electric cars are the best options. However, the energy is not our only rules. In addition, to transport the same amount of people, buses and/or bikes are the winners of space efficiency comparing to private cars. It is clear that to be sustainable does not simply mean adopting renewable energy; there are more requirements beside the energy source, such as how to distribute energies and to use spaces wisely.

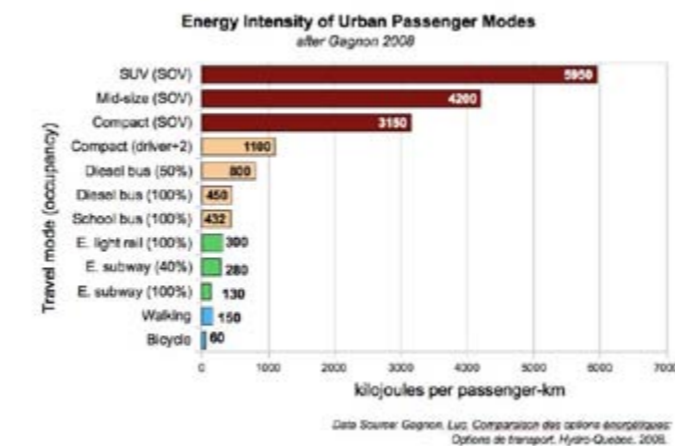


Figure 1.3 Energy intensity of urban passenger modes

Since the aim would not be achieved by replacing the energy source, we could search for the solutions from a spatial perspective. The traffic is close related to the city form, as it has been addressed in many researches. Some studies show regional accessibility has more impacts on the frequency and length of trips than density or land-use mix in the immediate area (Pushkar et al, 2000). Calthorpe (1993) argues for transit oriented development patterns in the premise that they would help manage the demand for travel. There is also some guidance tending to integrate urban planning and transport issue, and offer principles at the neighbourhoods level. Such as, the guidance for the design of eco-towns, provided by BioRegional and the Commission for Architecture and the Built Environment (CABE, 2008), Transport for Quality of Life (Taylor and Sloman, 2008), Policy Statement on Eco-towns (DCLG, 2008) or the LEED for Neighbourhood Development Rating System by Leadership in Energy and Environment Design. They all relate sustainable and quality urban life with transport. The criteria include coverage of accessibility, public transport, reduce car use, parking and good street design.

1.3. Research question

How to regenerate the existing road infrastructure and neighbourhoods to improve energy and space efficiency in Arnhem-Nijmegen city region in the Netherlands in 2050?

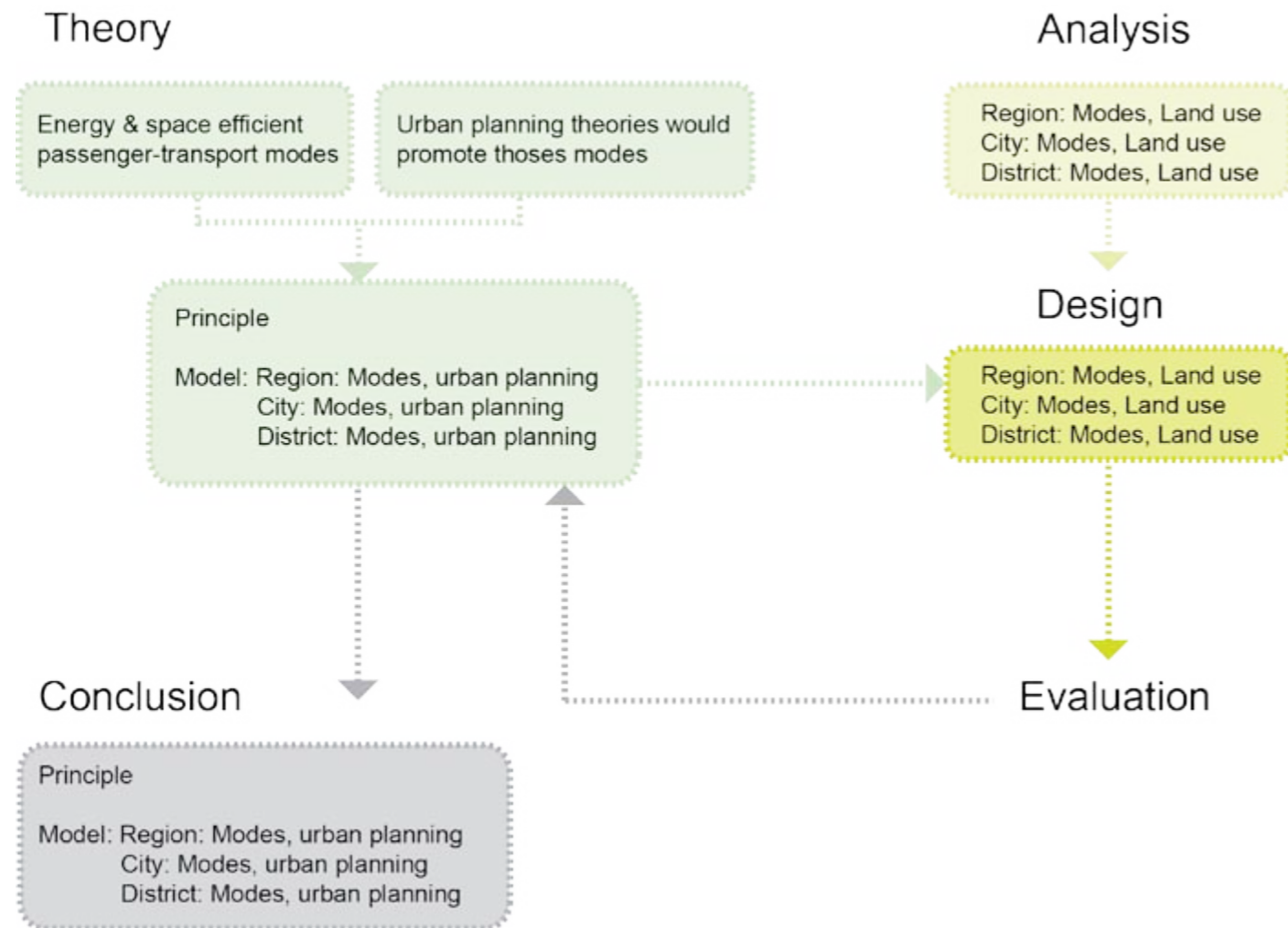
1.4. Sub research questions

- What modes of transport offer the most efficient use of energy and space? What are the suitable travel ranges for those transport modes? What are the spatial requirements for those transport modes?
- What are the best options of transport modes on regional scale, city scale and district scale? And how does the urban development relate to the road infrastructure?
- How to apply this model to Arnhem-Nijmegen city region on different scales (region/ city/ district)? What are the changes needed for the existing neighbourhoods?

1.5. Aims

The main goal of this project is to reduce the transport 's footprint in the city region by transforming the existing urban environment. To accomplish this, the project will be focus on two main aspects on regional, city and local scale: first, the project will concentrate on promoting the non-motorized transport modes and collective transport. Second the private cars, the project will deal with reducing the car use and making the private cars spatially efficient.

1.6. Methodology



1.7. Location

1.7.1 Region: City region Arnhem-Nijmegen

Arnhem-Nijmegen City Region is a metropolitan area located in the province of Gelderland in the east of the Netherlands. The region is flanked by the Randstad in the west, the Flemish Diamond to the south and the Ruhr to the east (Figure 1.4). Due to its geographical advantages, the region is a stepping-stone in one of the Europe's main transnational transport corridors. The road traffic is important for this region: highway A12 and A15 starts from Randstad in the west and ends in Ruhr area in the east (Figure 1.5).



Figure 1.4 Arnhem-Nijmegen City Region (coolregion, 2012)



Figure 1.5 Highway A12 and A15

The region consists of twenty municipalities and has a total population of almost 750,000 inhabitants. Its aim is to promote regional cooperation. Arnhem-Nijmegen City Region has expressed the ambition of becoming the second biggest economic area in the Netherlands after the Randstad by 2020 (Arnhem Nijmegen City Region, 2012).

1.7.2 City: Arnhem

Based on Arnhem-Nijmegen city region plan (Stadsregio Arnhem Nijmegen, 2010), highway A15 will be extended (Figure 1.6). This action is aimed to release the heavy traffic intensity on A12 and responds to the increasing traffic demands on this route. Arnhem city, with 150,000 populations by 2012, is the largest city in this region and is an important hub of the road transportation between Ruhr area and Randstad. The highway extension also emphasizes the important role of Arnhem as the distribution centre of the city region, by giving an opportunity for Arnhem to renew its south bank.

1.7.3 District: Arnhem central-south

The project mainly focuses on the south bank of Arnhem, because it is influenced by the highway extension directly. This bank is inhabited by almost half of city Arnhem's population, and divided into two parts by Highway A325 and N325. Since Highway A15 will extend and connect with Highway A12, the traffic intensity will reduce on Highway A325 and N325.

This change could be seen as a trigger for the transformation process of Arnhem south bank, especially in its centre zone. The centre zone refers to the area at the intersection of Highway A325 and N325. It is composed by three public buildings: the GelreDome Stadium, the Rijnhal and the Kronenburg shopping mall, which hold most big indoor events in Arnhem. However, the landscape in this area is wide streets, big box buildings with huge parking lots around them. It provides good accessibility for car-drivers, but kills the street life at the same time.

Part 2 Theory

2.1. Energy and space consumption of transport

Many data show the energy consumption of public transport and non-motorized transport modes are significant lower than the private motor vehicles (Figure 2.1). Since the alternative energy could be apply on private vehicles, the energy consumption drops (Figure 2.2), but still far from the ideal performance of collective transport modes. On the other hands, Figure 2.3 shows, in order to transport the same amount of people, the private cars requires much more spaces than the other two transport modes. 'Although only 5% of the total land use of this part of the Netherlands is for transport infrastructure, the indirect impacts on society as a whole are very large as we know from the daily news about parking problems in city centres, congestion on the motorways, the intersecting of green structures and the introduction of barriers due to the construction of new rail and road infrastructures, etc.' (Rooij, 2005, p.16)

Footprint of direct and indirect energy

Mode of transport	Energy consumption (Gj/passenger—km) (a)	Energy-to-land ratio (ha/Gj) (b)	Footprint ^a (ha/passenger—km) (a x b)
Car	0.00259	0.01	2.59×10^{-5}
Bus	0.00061	0.01	6.1×10^{-6}
Motorbike	0.00129	0.01	1.29×10^{-5}
Train	0.0013	0.0085	1.1×10^{-5}
Underground	0.0013	0.0085	1.1×10^{-5}
Bicycle	—	—	2.6×10^{-6} *

^a It does not include the land area taken by the infrastructures of transport.

* The ha/passenger—km required for bicycle is derived from annual footprint for bicycle for an individual who commutes 10 km each day proposed by Rees and Wackernagel (1996a, pp. 106) which is $0.0122 \text{ ha}/(10 \text{ km} \times 230 \text{ workdays} \times 2 \text{ trips}) = 0.0000026$.

Figure 2.2 Footprint of energy of different transport modes (Muniz & Galindo, 2005)

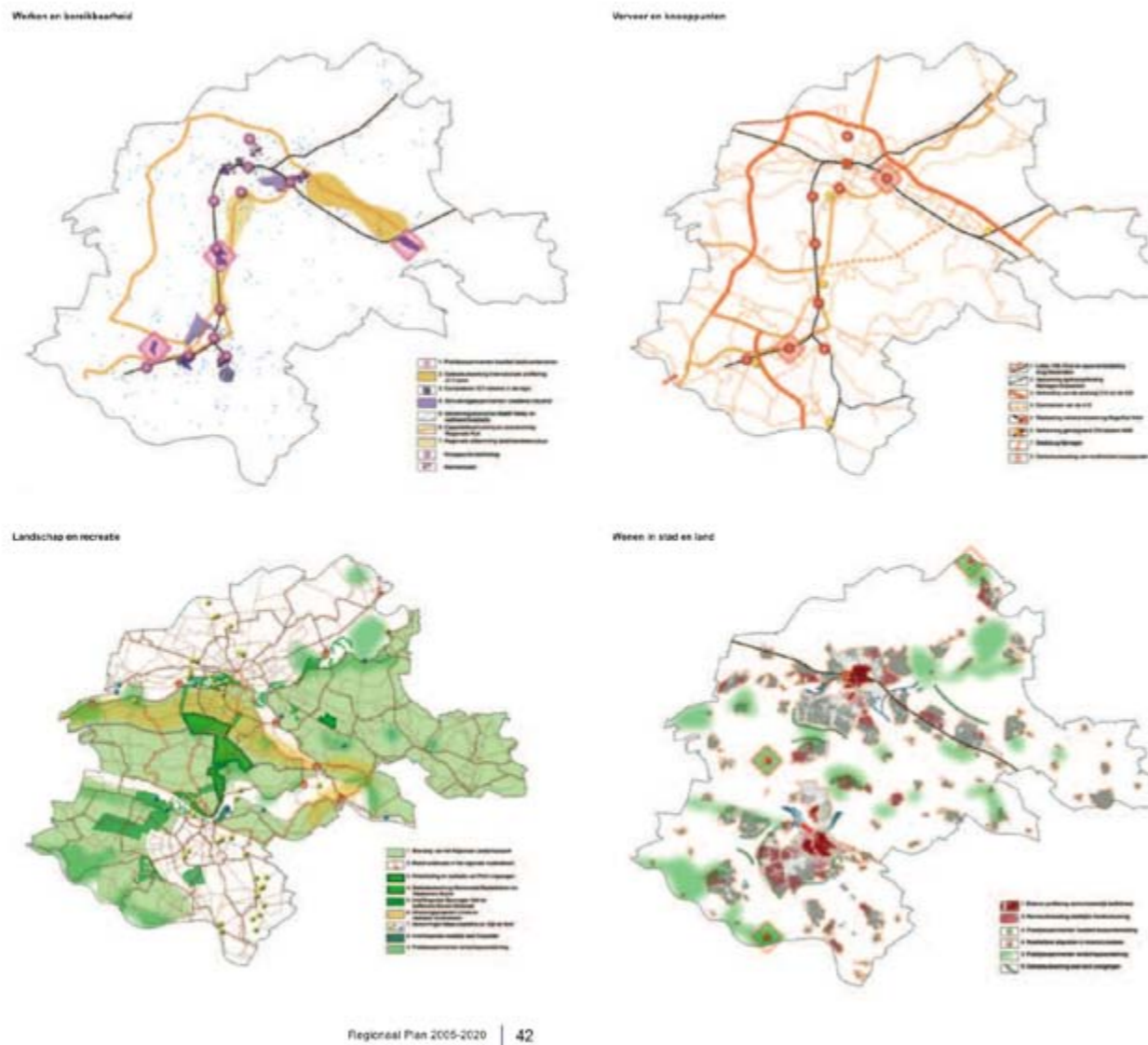


Figure 1.6 Regional plan for 2005-2020 (Stadsregio Arnhem Nijmegen, 2010)

Traffic is the vitals of Arnhem. That is the question: whether to suffer the dry street life from the over wide streets and huge empty parking lots, or to take action against car-oriented urban form. And by opposing, end them.

1.8. Final product

The project includes theory and design. After a review of existing urban development theories, which encourages sustainable mobility, and then related to Dutch city context, a model of urban development promoting energy and space efficiency will be addressed. After that, this model will be applied in a medium-sized Dutch city, an urban regeneration design in Arnhem south. Finally, this project will be evaluated and concluded.

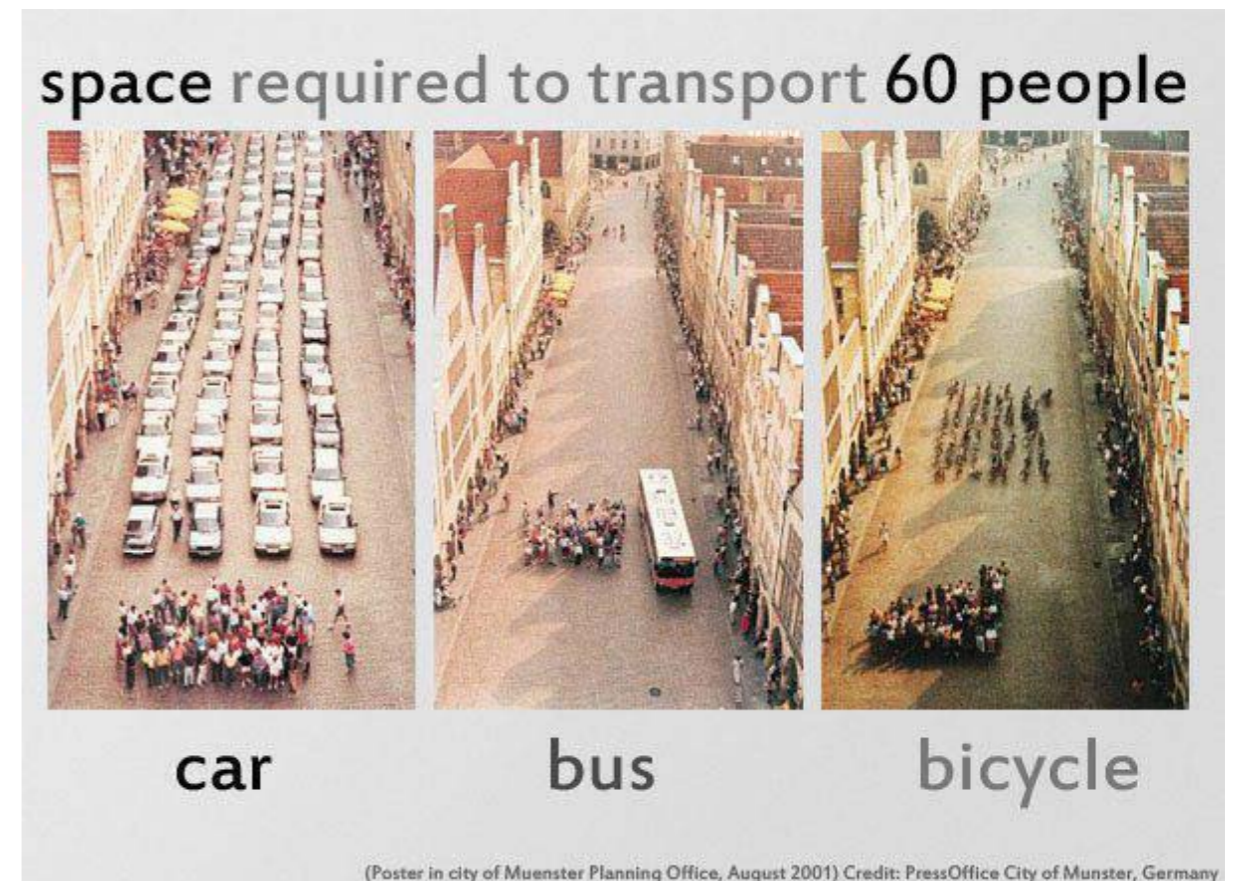


Figure 2.3 Spatial requirements of different transport modes

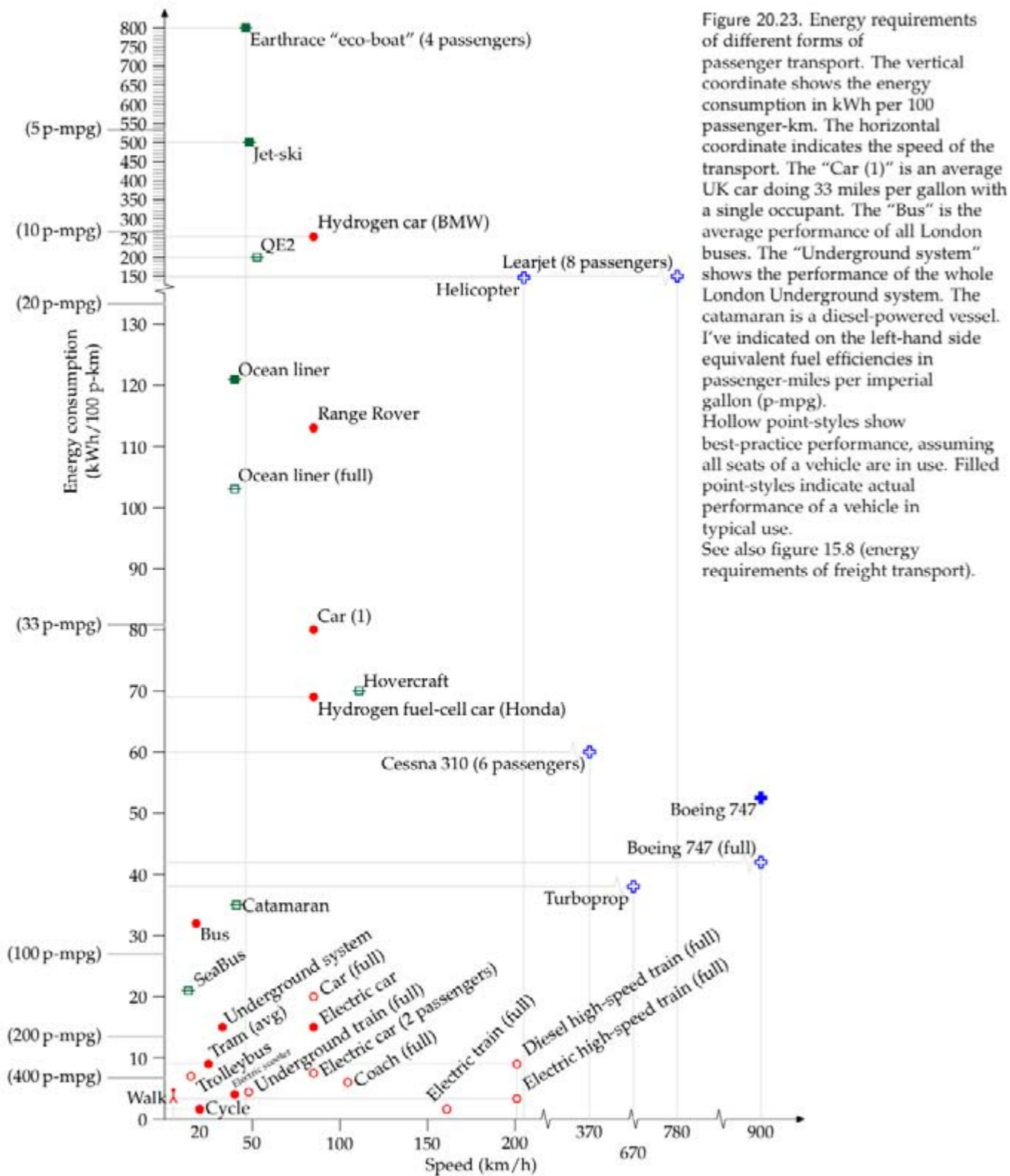


Figure 2.1 Energy requirements for different forms of passenger transport (MacKay, 2009)

Figure 20.23. Energy requirements of different forms of passenger transport. The vertical coordinate shows the energy consumption in kWh per 100 passenger-km. The horizontal coordinate indicates the speed of the transport. The "Car (1)" is an average UK car doing 33 miles per gallon with a single occupant. The "Bus" is the average performance of all London buses. The "Underground system" shows the performance of the whole London Underground system. The catamaran is a diesel-powered vessel. I've indicated on the left-hand side equivalent fuel efficiencies in passenger-miles per imperial gallon (p-mpg). Hollow point-styles show best-practice performance, assuming all seats of a vehicle are in use. Filled point-styles indicate actual performance of a vehicle in typical use. See also figure 15.8 (energy requirements of freight transport).

2.2. Approaches to sustainable urban development and urban transport

Energy use, CO2 emissions, air pollution, traffic noise, and the like are considered as the best indicators of the environmental impact of urban transport, and all the elements are related to travel distance. Hence, the 'per capita distance traveled by car' is the most widely accepted (un)sustainability indicator of urban transport (Wegener & Furst, 1999). From this perspective, the challenge for sustainable urban development and urban transport becomes that of achieving urban development with no, or as little as possible, increase in car use (Bertolini & le Clercq, 2002).

Lam and Head (2012) proposes the following strategies for cities with sustainable urban mobility.

- Integrated urban planning and design;
- Expanding eco-vehicle use;
- Enact behavioral change;
- Low emissions policy.

According to their research, these strategies implemented at various scales and degrees by other cities and they have shown to decrease carbon emissions, improve environmental quality, and serve greater economic and social value.

However, this strategy is quite general. In another report (Little, 2011), based on the developments of different countries and cities, to meet the urban mobility challenge, three strategic imperatives are given:

- Network the system: for high performing cities the next step must be to fully integrate the travel value chain, increasing convenience by aggressively extending public transport, implementing advanced traffic management systems and further reducing individual transport through greater taxation and road tolls.

- Rethinking the system: Cities in mature countries with a high proportion of motorized indi-

vidual transport need to fundamentally redesign their mobility system so that they become more consumer and sustainability orientated. The group contains the majority of cities in North America along with those in Southwestern Europe.

- Establish a sustainable core: For cities in emerging countries the aim must be to establish a sustainable mobility core that can satisfy short-term demand at a reasonable cost without creating motorized systems that need to be redesigned later. With access to new and emerging transport infrastructure and technologies these cities have the opportunity to become the test bed and breeding ground for tomorrow's urban mobility systems.

In this report (Little, 2011), Amsterdam is one of the highest performing cities. We could boldly assume most Dutch cities belong to this group, which means the transport system works well, but need to upgrade the traffic management and further reduce individual transport.

Black (2010) mentions the Netherlands's approach to sustainable transport in his book, 'the automobile has created unacceptable levels of congestion, thereby decreasing accessibility. The congestion can only be reduced through massive public investment in new facilities, entailing major impacts on the environment.' (Black, 2010, p.173) In this approach, it recommends: limited infrastructure expansion, clean energy on motor vehicles, promote alternate transport modes, increase the density and offering mix use. However, all this suggestions are lack of continuous structure, and it can hardly be realized by leaving out the impact of urban spatial structure on travel patterns.

To sum up, the possible strategies for sustainable urban development and urban transport in Dutch context are:

- Integrate urban planning and design with transport pattern. Developing conditions for as large as possible a share of the more space

and energy efficient transport modes in urban mobility, while at the same time maintaining, and possibly increasing, the amount and the diversity of activity places that can be reached within an acceptable travel time.

- Encourage the use of energy and space efficient transport modes and enact behavioral change, promoting non-motorized transport. Increasing convenience by aggressively extending public transport and integrating the public transit with car or bike parking facilities.

- Limit private car use in high-density areas and maximize the space and energy efficiency.

2.3. Suitable range for different transport modes

Different transport modes service their own spatial level, and it is determined by the average speed, stop distance, operation cost, capacity, etc. However, 'a specific subsystem that is ideal for a certain distance class, could also fulfil travel needs for somewhat shorter and somewhat longer distances. This means that for certain travel distances, there are two appropriate systems (Figure 2.4).' (Rooij, 2005)

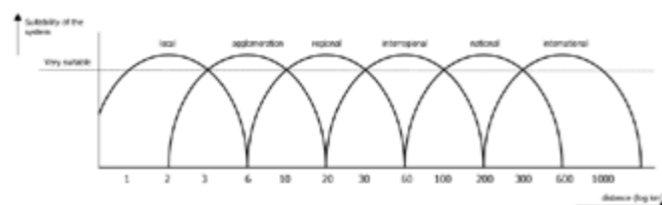


Figure 2.4 Overlap collective transport systems (Rooij, 2005)

'On average 60% of all trips are shorter than 5 kilometres, and 75% shorter than 10 kilometres. The slow modes bike/moped and walking attract 45% of all trips made. 80% of the public transport trips are longer than 5 kilometres. (Figure 2.5)' (Rooij, 2005, 39)

Travel distance	Car	Public transport	Bicycle	Walking	Total
0.0 – 2.5 km	22	1	40	37	100 = 45%
2.5 – 5.0 km	50	3	40	7	100 = 16%
5.0 – 7.5 km	64	5	26	5	100 = 11%
> 7.5 km	75	11	7	0	100 = 28%
Total	46%	5%	29%	18%	100%

Source: PblVVS, 1998b

Figure 2.5 Average number of trips per person per day of the Dutch population in 2001 (Rooij, 2005)

Study suggests mono-modal transport is attractive for short-distance trips or for trips where origins and/or destinations are not located near any inter-modal transfer points. Multimodal transport is only attractive if the trip travel time, the trip travel costs, and/or the service outweigh the loss of time and comfort during the process of the transfer. Comparing to mono-model transport, although multimodal transport has a small share of all trips, nearly 3%, it has potential in the long-distance trips between urban

conurbations. 'This share increases if typical trip types are considered, for instance, 20% of all interurban trips to the main cities in the Netherlands, or 80% of all train trips (Figure 2.6)' (Rooij, 2005, p.40)

	Travel distance	Stop distance	Travel speed
Intercontinental	1,000+ km	450+ km	180+ km/h
International	300 – 1,000 km	150 km	150 km/h
Plane, high-speed train			
National	100 – 300 km	50 km	120 km/h
Intercity train			
Interregional	30 – 100 km	15 km	90 km/h
Fast train			
Regional	10 – 30 km	2 km	60 km/h
Stoptrain, light rail			
Agglomeration	3 – 10 km	800 – 1,000 m	30 km/h
Metro, fast tram			
Local	1 – 3 km	300 m	20 km/h
Bus, tram			

Source: Advisory Council for Transport, Infrastructure, and Water Management, 1996

Figure 2.6 Collective transport and spatial level (Rooij, 2005)

Figure 2.7 identifies the following characteristics of the main public transport modes, focusing on capacity, capital cost, operating cost, average speed, reliability, road space allocation and land use integration (Luke, S. & MacDonald, 2006).

Mode	Bus	Maximum bus Priority	Busway	Tram	Light rail	Heavy rail
Characteristics						
Maximum capacity	2,500 pphpd	4,000 pphpd	6,000 pphpd	12,000 pphpd	18,000 pphpd	30,000+ pphpd
Capital cost per route km	< £1m	£1m - £2m	£1m - £20m	£15m - £20m	£10m - £45m	£45m - £250m
Operating cost per passenger place km	3.8 p - 8.8 p	2.5 p - 5.8 p	2.5 p - 5 p	1 p - 2.1 p	1 p - 1.4 p	1.5 p - 1.8 p
Average speed	15-14 km/hr	14-18 km/hr	15 - 22 km/hr	15 - 22 km/hr	18-40 km/hr	18-40 km/hr
Reliability	Improving	Medium	Good	Medium to Good	Good	Very Good
Roadspace Allocation	Mixed running with traffic	Mixed running and overlaid bus lanes	Totally segregated alignment required	Mixed running and overlaid tram lanes and totally segregated where suitable	Very largely on segregated alignments	Totally segregated
Theoretical Land Use level	Best suited to lower density dispersed urban form	Best suited to lower density dispersed urban form	Best suited to high demand corridors in medium to low density areas	Higher densities of development, or connecting donor urban centres	Higher densities of development, or connecting linear urban centres	Very high density urban development

Source: Transport for London

Figure 2.7 Collective transport and characters

2.4. Dutch city context

In Figure 2.8 and Figure 2.9 and Figure 2.10, using the unit squares to show the area of Dutch cities. Mostly, Dutch city region is about 1600 square kilometres (40km*40km), Dutch city is around 25 square kilometres (5km*5km), and the traditional Dutch city centres could be covered by 0.25 square kilometres (0.5km*0.5km). Thus, the approximately travel distance on regional scale is 10 to 60 km, travel distance on city scale is around 2 to 20 km and on local scale is 0 to 4 km, which refer to the spatial level of regional, city and local transport modes, respectively.

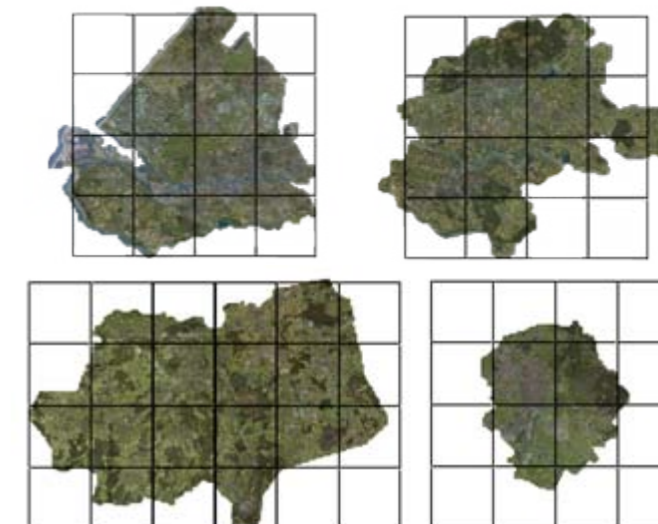


Figure 2.8 Dutch city regions

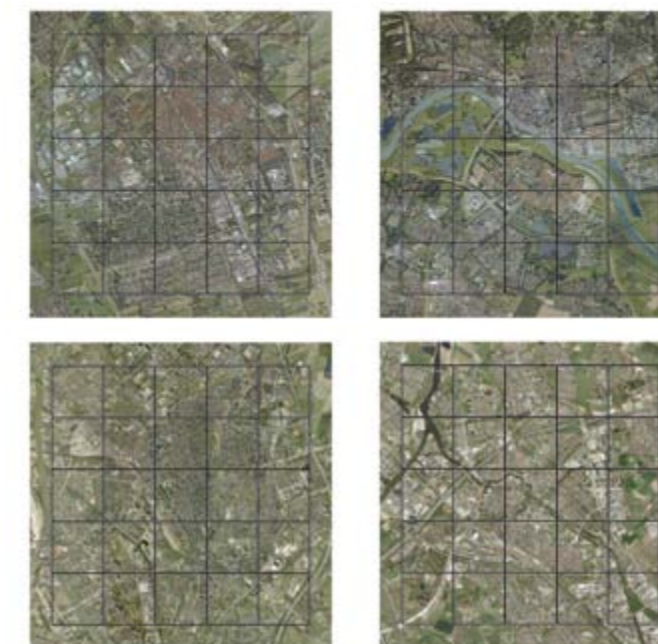


Figure 2.9 Dutch cities



Figure 2.10 Traditional Dutch city centres

2.5. Model – Region

Transport mode is an essential factor in defining transit's area of influence, together with other factors such as right of-way and stop and station spacing. Transit technologies (BRT, LRT, heavy rail, etc.) can fit more than one category of transport mode, depending on the design and level of investment. A single route or transit line may incorporate characteristics of more than one transport mode (APTA, 2009). Figure 2.11 indicates the possible options for rapid transit on regional scale are BRT and LRT.

Transport Modes ¹						
Mode	Right-of-Way Characteristics	Level of Investment in Transit Facilities	Typical Stop/ Station Spacing	Vehicle Speed	Service Reliability ²	Typical Transit Technology
Local street transit	Operates in mixed-flow with automobile traffic.	Minimal infrastructure investments	1/8 to 1/4 mile (depends on block size)	Low (in traffic)	Low (in traffic)	Local bus, streetcar
Rapid street transit	Operates in mixed-flow with automobile traffic, sometimes with partially dedicated or shared lanes.	Some investment (shelters, signage, etc)	1/5 to 1/3 mile	Low (in traffic) to moderate (in dedicated lanes)	Low (in traffic) to moderate (in dedicated lanes)	Rapid or express bus, streetcar
Somirapid transit	Operates in dedicated right-of-way with regular crossings.	Moderate to heavy investment (platforms, shelters, lighting, etc)	1/3 to 2/3 mile	Moderate	High	BRT, LRT
Regional transit	Operates in dedicated right-of-way with limited crossings.	Moderate to heavy investments (platforms, shelters, lighting, etc)	3/4 to 3 mile	High	High	BRT, LRT, commuter rail
Rapid transit	Operates in dedicated right-of-way with grade separation.	Heavy investment (stations/protected waiting areas)	1/3 to 1 1/3 mile	High	High	Heavy rail

1. Adapted from Vuchic, Vukan, *Urban Transit, Systems and Technologies*, p. 76, 2007. The characteristics listed here are intended to be descriptive of existing service types, and do not constitute a recommended practice.
 2. Though service reliability can vary substantially based on local conditions, vehicles operating in exclusive right-of-way with limited grade crossings typically have greater reliability than those operating in mixed traffic.

Figure 2.11 Regional transport modes comparison (APTA, 2009)

2.5.1 Light rail and bus-based systems

Whilst light rail and bus-based systems have been considered to offer passenger-transport in the similar spatial level, some research shows there is some significant difference in their characteristics.

According to the PTEG (2005) some of the main advantages of Light Rail include:

- Ability to penetrate town and city centre with permanent, visible and acceptable infrastructure;
- Delivery of predictable, regular and reliable journey times and service patterns;
- Accessible and visible stops;
- A high ride quality throughout the entire journey;

- ney;
- Short dwell-times, owing to multiple doors and off-vehicle ticketing;
- High passenger carrying capacity and additional capacity in a sustainable way;
- Effective integration with park and ride facilities, major traffic attractors and new developments;
- Opportunities to renew both the fabric of the urban areas it serves, and the image of those areas;
- Permanence of infrastructure, vehicles and operations, creating confidence amongst individuals and business to settle that produce long-term patronage growth.

Bus rapid transit (BRT) is an evolving public transportation mode consisting of rubber-tired vehicles running on dedicated rights-of way for all or part of a transit route. All the advantages mentioned above also apply to BRT system. In addition, there are some other good things about bus systems, for it has been applied in several cities successfully. Firstly, the investment of bus service system is lower than light rail system. '... Curitiba selected buses as a means of public transport because they are flexible and considerably cheaper than trams and underground rapid transit.' (Gehl et al., 2001, p.69) Secondly, the advantage of the flexibility of bus service system is obvious: the service routes are easier to change than the light rail, and so is the capacity. According to Harkness (2003) Buses operating on high-occupancy vehicle lanes are capable of carrying several times more passengers than light rail will ever be able to carry. If the intent is to invest in transit with enough capacity to handle an area's needs far into the indefinite future, BRT is the better choice.

A recent research (Puchalsky, 2005) compares light rail and bus service system for the pollution gas emission view. Figure 2.12 and Figure 2.13 and Figure 2.14 show NOx, volatile organic compounds (VOCs) and CO emission results respectively. Light Rail Transit (LRT) outperforms Bus Rapid Transit (BRT) in both standard

and superior comparisons with the compressed natural gas (CNG) bus performing especially poorly. 'The results show that, although advances in diesel technology have radically improved bus emissions, LRT systems still produce less regional or urban emissions in the three categories considered than BRT systems.' (Puchalsky, 2005, p.35)

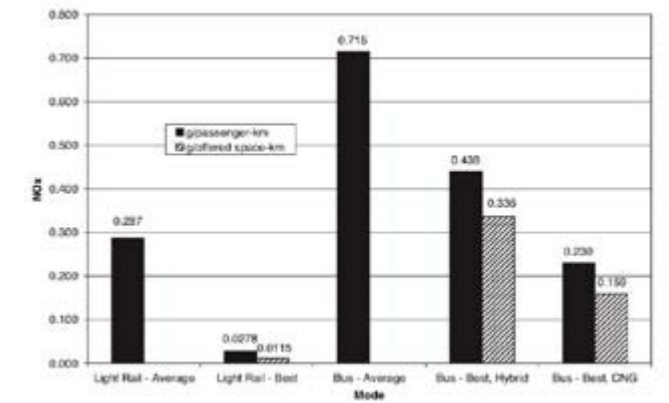


Figure 2.12 Comparison of NO emissions from LRT and BRT systems (Puchalsky, 2005)

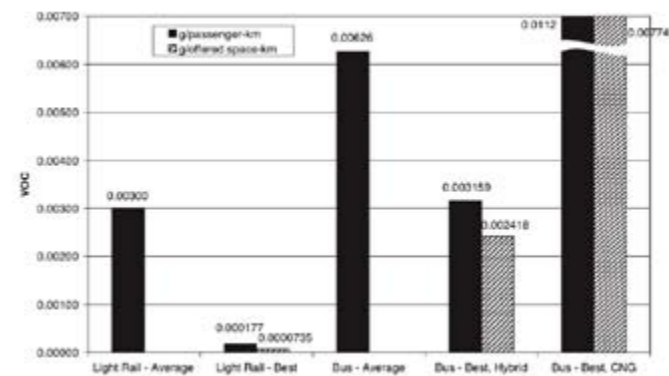


Figure 2.13 Comparison of VOC emissions from LRT and BRT systems (Puchalsky, 2005)

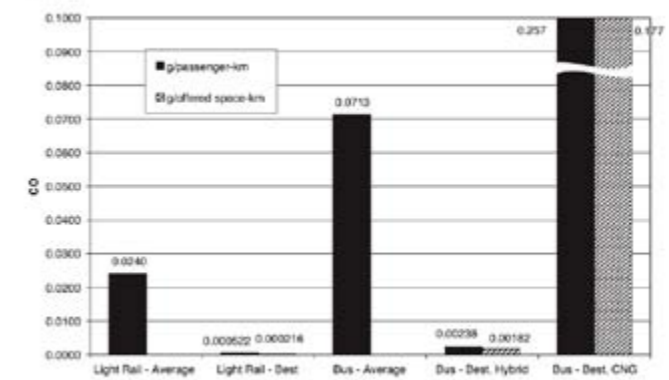


Figure 2.14 Comparison of CO emissions from LRT and BRT systems (Puchalsky, 2005)

It is irresponsible to conclude which system is better. The decision should be made after considering all the limiting factors: population, economy, travel behavior, travel distance, environment etc. However, it is clear that both LRT and BRT are ideal collective passenger-transport modes on regional scale.

2.5.2 Regional city and transit oriented development

The idea of a regional city is not a new one. Calthorpe (2001) explained this idea systematically in his book, people must leave behind the notion of the metropolis as a series of disconnected places, plan and design regions as a unit, owing to the economic, ecological, and social connections among residents and communities in today's metropolitan region are strong and complex. As he explains, 'metropolitan life throughout the nation now rests on a new foundation of economic, ecological, and social patterns, all of which operate in unprecedented fashion at regional scale.' (Calthorpe, 2001, p.16)

The relationship of transport and land use is the central focus in Calthorpe's theory. 'The two most basic components of regional design at this level are transportation facilities and land-use patterns. Indeed, these two components are intertwined so tight that it should be virtually impossible to separate them.' (Calthorpe, 2001, p.68) He has a strong opinion about highway construction, as it is the main cause of auto-dependent communities. Calthorpe (2011) points out the failure of more construction of highways, 'the central flaw in this autocentric system is the arterial road. Lacking multiple, distributed routes, all local trips are forced to turn onto and off the arterial, causing intersection overload. The arterial road is designed for speeds that it never delivers, mostly because of congestion and frequent, long stoplights. This is all made worse by the need for long, multiphase signals because of left turns. ... This useless high-speed design makes the road inhospitable to pedestrians and bikers, without

really delivering convenience for cars.' (Calthorpe, 2011, p.79) According to him, most highway congestion cannot be solved with more roads or with more transit for the long-term. In addition, his proposal to this problem is 'only walkable urban neighbourhoods and districts can permanently solve the transportation and congestion conundrum.' (Calthorpe, 2011, p.90)

In order to encourage public transport use and differentiate the development from urban sprawl, Peter Calthorpe (1993) defines transit oriented development (TOD) as moderate and high-density housing, along with complementary public uses, jobs, retail and services, are concentrated in mixed-use developments at strategic points along the regional transit system. He summarizes the main characteristics and goals of TOD as follows:

- Organize growth on a regional level to be compact and transit-supportive.
- Place commercial, housing, jobs, parks, and civic uses within walking distance of transit stops.
- Create pedestrian-friendly street networks, which directly connect local destinations.
- Provide a mix of housing types, densities, and cost.
- Preserve sensitive habitat, riparian zones, and high quality open spaces.
- Make public spaces the focus of building orientation and neighbourhood activity.
- Encourage infill and redevelopment along transit corridor within existing neighbourhoods.

As Calthorpe (2001) argues, 'the central notion of TODs was that clustering jobs, services, and housing in areas served by transit would give people several convenient alternative to the car: walking, biking, carpooling, buses, and rail.' (Calthorpe, 2001, p.110) His appraisal on Portland metro's framework plan 2040, 'in the past, highways had formed the armature of growth for the region, but, in the 2040 Plan, transit corridor create the new backbone.' (Calthorpe, 2001, p.121)

In 2002, a research for the California Department of Transportation notes, 'Transit-Oriented Development (TOD) is moderate to higher density development, located within an easy walk of a major transit stop, generally without excluding the auto. TOD can be new construction or redevelopment of one or more buildings whose design and orientation facilitate transit use.' (California Department of Transportation, 2002) This research mentions parking reductions for TOD. 'Research indicates TOD offers the potential to reduce parking per household on the order of approximately 20%, as compared to non transit-oriented land uses. A wide range of parking reductions has also been found for commercial parking in TODs.' (California Department of Transportation, 2002, p.10) TOD offers opportunities to reduce the number of parking spaces by increasing transit accessibility and combining a mixture of land uses. In result, the number of parking spaces in TODs will be lower than the conventional parking requirements typical for retail, office and residential land use. Reduced parking requirements can lower TOD construction costs, which in turn helps make housing more affordable and allows more development to be built on sites near transit.

2.5.3 Plug-in hybrid electric vehicles and charging facility

However, the individual passenger transport will not be vanished in 2050. Ideally a certain percentage of automobiles will adopt alternative energy, while the gasoline could be use on heavy and long-distance transportation. For the urban daily use of light-duty vehicles, the primary alternative energy sources are hydrogen and electricity. Plug-in hybrid electric vehicles (PHEVs) use batteries to power an electric motor and use another fuel, such as gasoline or diesel, to power an internal combustion engine or other propulsion source. Using electricity from the grid to run the vehicle some or all of the time reduces operating costs and petroleum consumption, relative to conventional vehicles (Figure 2.15).



Figure 2.15 Plug-in hybrid electric vehicles

In Plug-in Hybrid Electric Vehicle Charging Infrastructure Review (Morrow et al., 2008), '40 miles of charge depleting range is necessary for an average PHEV if no infrastructure is available outside of the owner's primary residence. If public charging infrastructure is available, allowing PHEV charging outside of the owner's primary residence, the charge depleting range can be lowered to 13 miles (21km). It is, therefore, considered important to evaluate charging infrastructure in both residential and commercial settings because the availability of a rich charging infrastructure can reduce the onboard energy storage requirement (i.e., battery size) for PHEVs.' (Morrow et al., 2008, p.9) That is, when comparing the cost of onboard electronics and a battery to support a larger (PHEV-40) battery versus a smaller (PHEV-10) battery for a mid-size vehicle, the cost for a better battery is higher than the cost of provide additional commercial facility charging infrastructure. This would allow the reduced range PHEV-10 to be used as effectively as the longer range PHEV-40. Although from this perspective, it is reasonable to have shorter charging depleting range, 21 km is too short for car drivers. For instance, the distance between Den Haag and Rotterdam is about 24 km, if a car travels with the average speed of 60km/h, the trip takes 24 minutes, but the car needs to charge once before it arrives its destination. It probably would

not work in the reality. Due to most regional travel distance is from 6-60 km, I would say a regional trip around 30 minutes with the speed of 60 km/h is reasonable, that is about 30 km. The charging depleting range should be around 30 km. In this situation, people would not sacrifice their convenient for lower investments on electric vehicle charging facilities.

On the other hand, unlike the petrol station, the typical PHEV charging infrastructure could be (1) overnight charging at a home garage, (2) overnight charging at an apartment complex, and (3) opportunity charging at a commercial facility. The charging infrastructure could be combined with parking lots next to public buildings, such as shopping malls and offices. If the charge depleting range can be lowered to 13 miles (about 21 km), on the regional plan, the distance between town centres could be set around 20 km or less, which means the regional travelers with private cars could stop at town centres for charging their PHEVs. During the break, they could hang around the centres; instead the regional travelers with diesel cars have to sit in a fast-food restaurant next to the gas station.

2.6 Model – City

2.6.1 Electric bike

On the city scale, the most common transport modes are cars, buses, light rail and bikes. To accomplish the aim that reducing the energy consumption in 2050, urban development should promote the public transport and non-motorized transport modes.

Cycling is very popular in the Netherlands and it is an ideal transport mode for sustainable development. The bicycle is used for more than a quarter of all journeys in the Netherlands (Ministerie van Verkeer en Waterstaat, 2009). In fact for distances up to 7.5 km, the bicycle is the most popular means of transport. In 2007, 34% of all trips up to 7.5 km were made by bicycle (Figure 2.16). As the data (Figure 2.1) shows before, cycling consume less energy than walking and most of other transport modes. Despite the intuitive sense that electric bikes would require more resources than conventional bikes, life-cycle analysis (Lemire-Elmore, 2004) shows that they actually consume 2-4 times less primary energy than human riders eating a conventional diet (Figure 2.17).

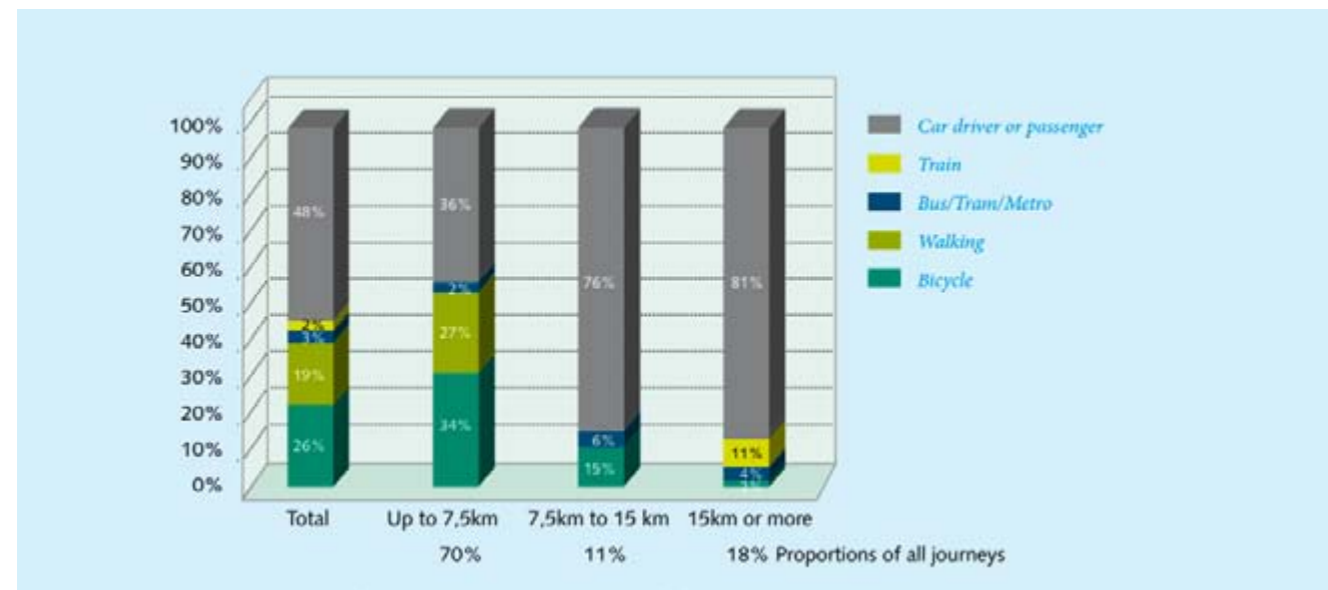


Figure 2.16 Journeys according to main transportation means and distance category in 2007 (Source: Ministerie van Verkeer en Waterstaat, 2009)

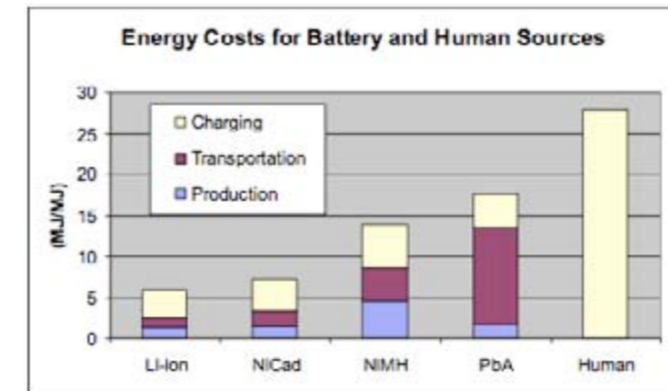


Figure 2.17 Life cycle energy requirements (Lemire-Elmore, 2004)

Besides the merit on energy intensity, electric bikes also have advantages on speed and could reach further destination within limited time comparing to conventional bikes, they have potential to be an alternative option for car drivers along with buses or light rail.

'Electric bikes should be encouraged to the extent that they displace car or motorcycle use.' (Cherry et al., 2008, p.289) The authors did a research on comparative environmental impacts of electric bikes in China. The result shows that the majority of electric bike users are previous bus or bike riders and would use a bus or bike in the absence of an electric bike. The electric bike performs well in terms of environmental impacts compared to the bus and the motorcycles. Although electric bike SO₂ emissions are considerably higher, other pollutants are lower than or on the same order of magnitude of bus emissions. The study also touches Lead pollution, the biggest environmental reservation associated with electric bikes. The Lead emissions mainly come from production, recycling and disposal processes of batteries. However, Lead acid batteries are not necessary for electric bike operation, it could be replaced by alternative technologies, such as nickel metal hydride (NiMH) and lithium-ion (Li-ion) batteries, which are much more expensive, but also have much higher energy densities and longer lifespan. (Cherry et al., 2008) As Cherry (Cherry, 2007) answers in another report, nickel metal hydride (NiMH) and lithium-ion (Li-ion) batteries would increase the purchase price of

an electric bike by 20-25%, and increase the operating cost by about 100%. Even with these increased costs, the cost-effectiveness of travel is still lower than any other modes. Figure 2.18 Shows the cost effectiveness of traveling 100 kilometers by various alternative modes, including internal costs and external costs.

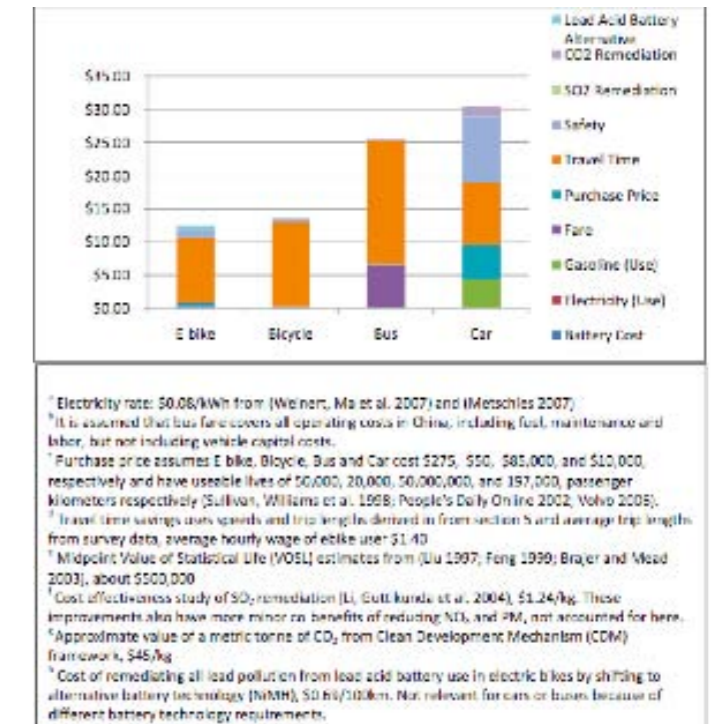


Figure 2.18 Cost effectiveness of traveling 100 kilometers by various alternative modes, including internal costs and external costs (Cherry, 2007)

2.6.2 OV-Fiest service

OV-Fiest is a pilot project in the Netherlands that started in 2002, aiming at making the bike a part of the public transport system. After 10 years, the OV-Fiest is a mature system and is an ideal means to cover the distance between the railway station and the office. In order to encourage the electric bike use in the city scale, the efficient way is to deploy more electric bikes in OV-Fiest service spots.

ELECTRIC BIKE

VS.

CONVENTIONAL BIKE

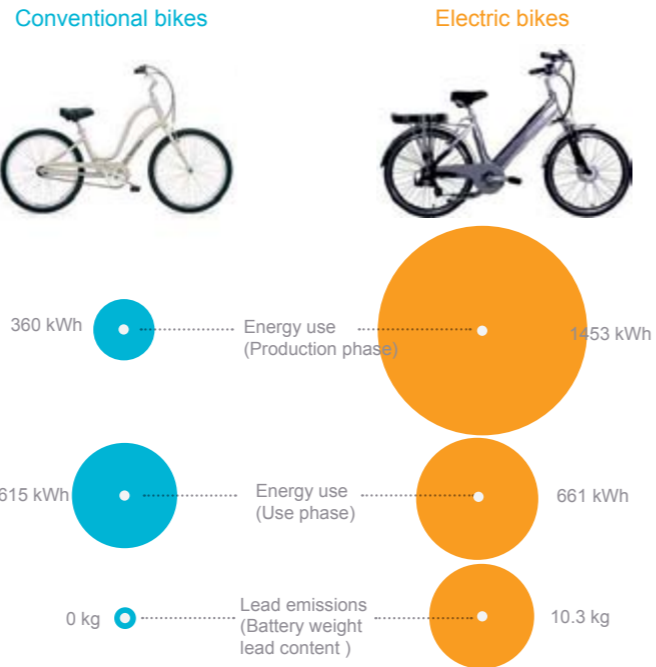
how do their performance compare?

Electric bike use has skyrocketed over the past decade, especially in China. It comes in many styles and performance characteristics, but the primary technology is the same. The vast majority rely on lead acid batteries to provide energy to a hub motor, usually on the rear wheel.

The growing popularity of electric bikes has raised concerns about its safety and environmental impacts. Are electric bikes a step above bicycles in the modal transition to cars or are they primarily a low-cost mobility option to public transit?

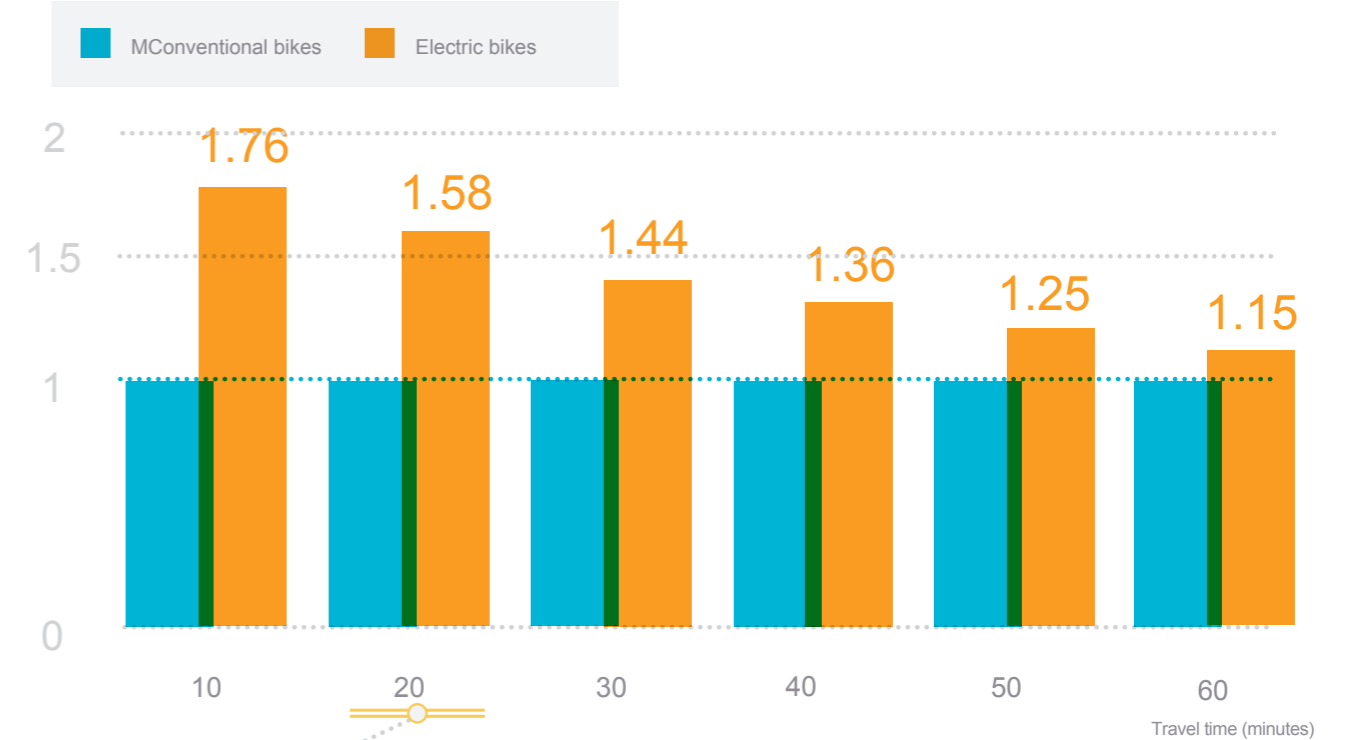
All data was collected by Christopher Cherry and Robert Cervero in Shanghai, China during 2006.

ENERGY STATS



ACCESSIBILITY INDEX OF JOBS

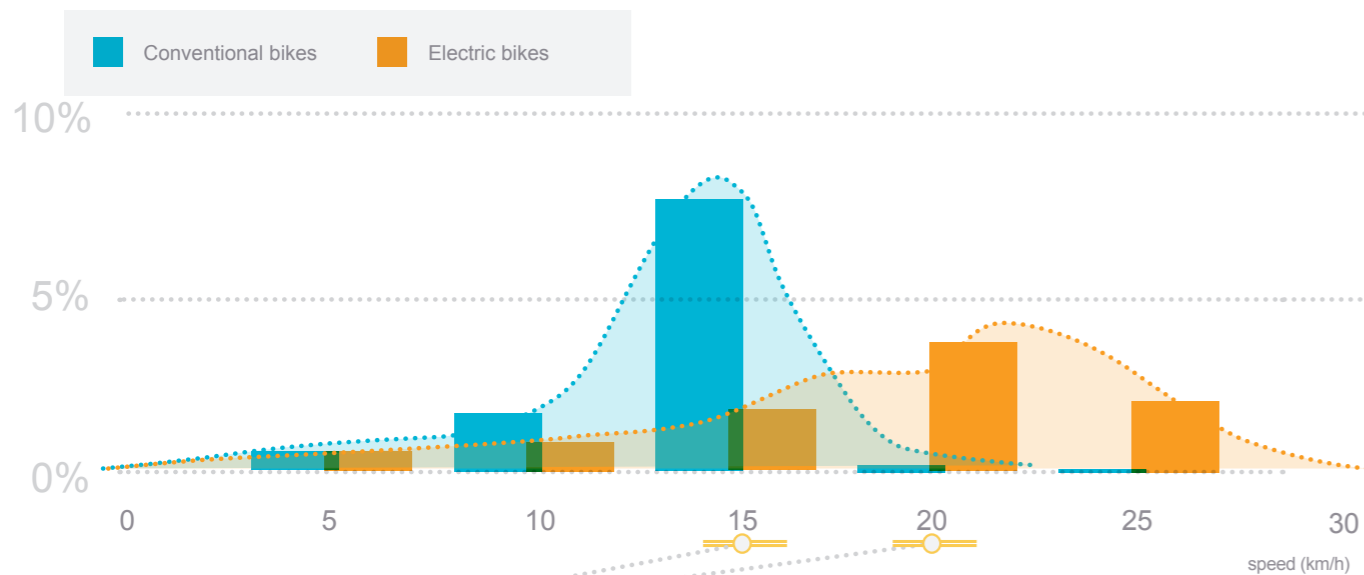
It shows the accessibility indices for electric bikes compared to bicycles.



Electric bikes have the highest accessibility advantage over alternative modes for short trips. It provides 58% more accessibility to jobs than a bicycle within 20 minutes.

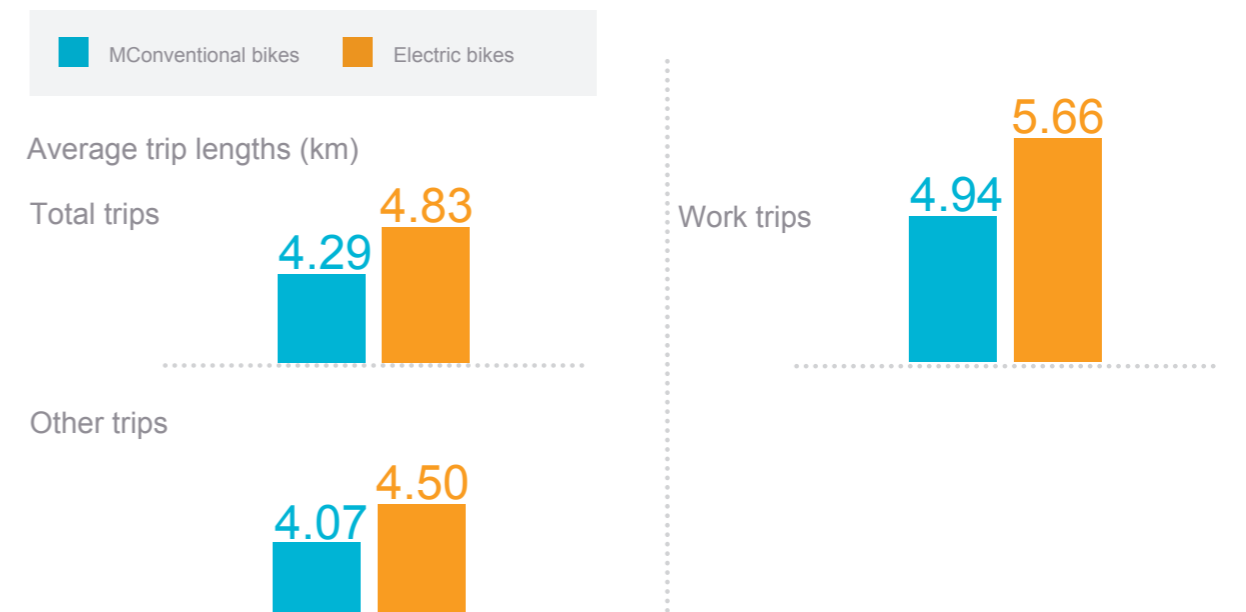
SPEED RANGE

It shows the speed distributions for electric bikes and bicycles. The speed studies were conducted for bicycles and electric bikes during the morning and evening peak travel periods on a subset of major commute routes in Shanghai.



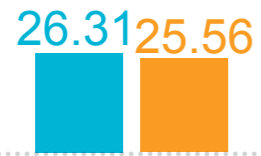
The figures show that electric bike users do in fact travel significantly faster than bicyclists. The average speed (not including stops) is about 18 km/hr, or 40% higher than the average speed of bicycles (13 km/hr).

TRAVEL CHARACTERISTICS

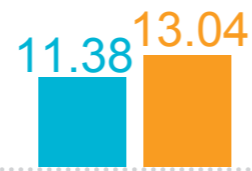


Average trip

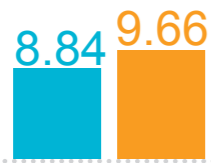
Travel time (min)



Speed include stops (kph)



Weekday vehicle kilometers traveled



The trip length was calculated as the network distance between stated origins and destinations. Mean travel times were similar across modes. Thus, while faster speeds allow longer distance travel.

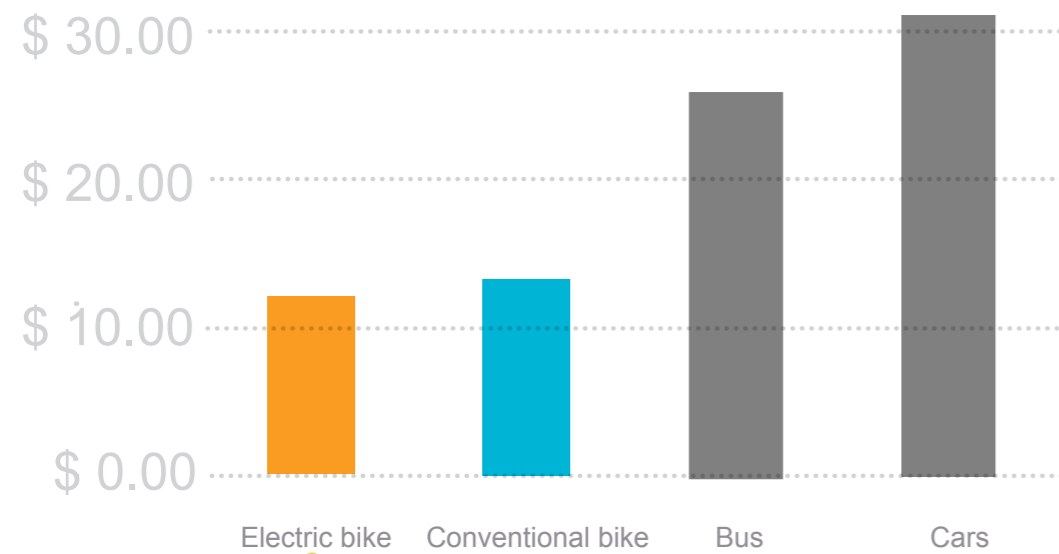
OV-FIEST TYPES, RULES AND COST



Rules	OV-fiets	Elektrische OV-fiets	NS-scooter
Rules	€ 10.00 per year subscription postpay direct debit rent up to 72 hours		
Cost	€ 3 / day € 5 / day (24 - 72 hours)	€ 7,50 / day € 5 / day (24 - 72 hours)	€ 7,50 (3 hours) € 15 / day

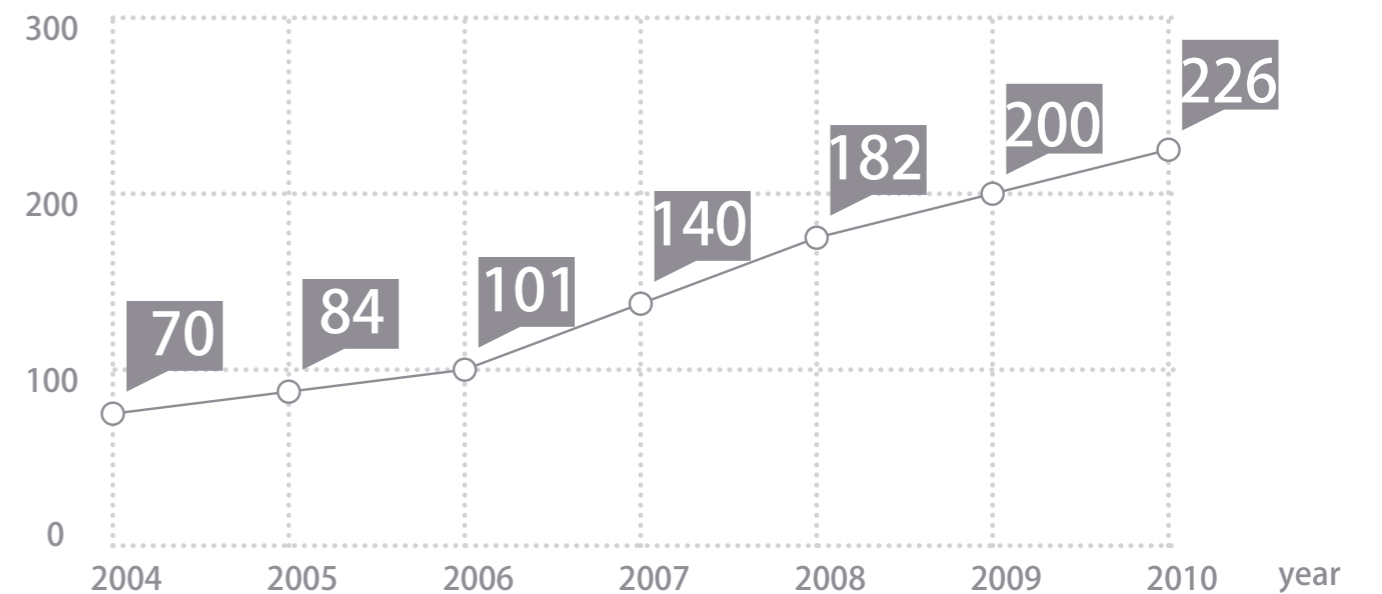
COST EFFECTIVENESS

It shows the cost effectiveness of traveling 100 kilometers by various alternative modes, including internal costs (travel time, out-of-pocket costs) and external costs (pollution remediation, safety, public subsidy).



Electric bikes provide high levels of mobility with very low user costs. However, lead pollution from the use of lead acid batteries is a negative externality. There are alternative battery technologies that can be used, which will mitigate the lead pollution problem, but increase the cost of electric bike use by 20-25% of the purchase price, and increase the operating cost by about 100%. Even with these increased costs, the cost-effectiveness of travel is still lower than any other modes.

AMOUNT OF LOCATIONS

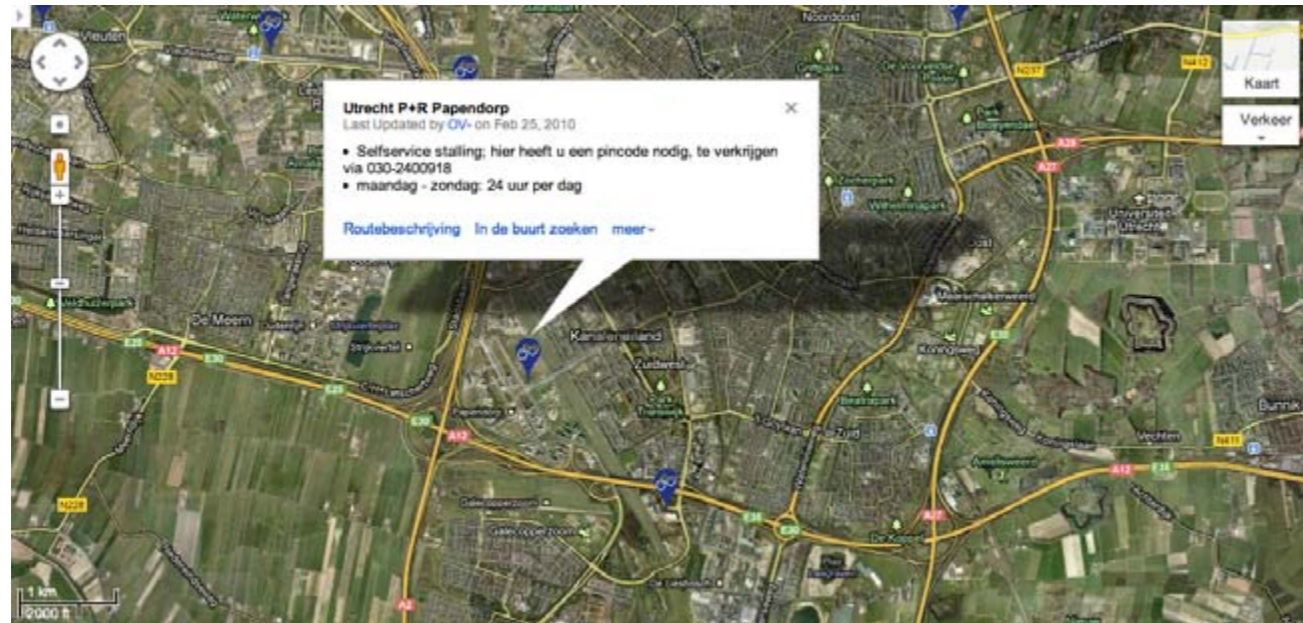


LOCATIONS

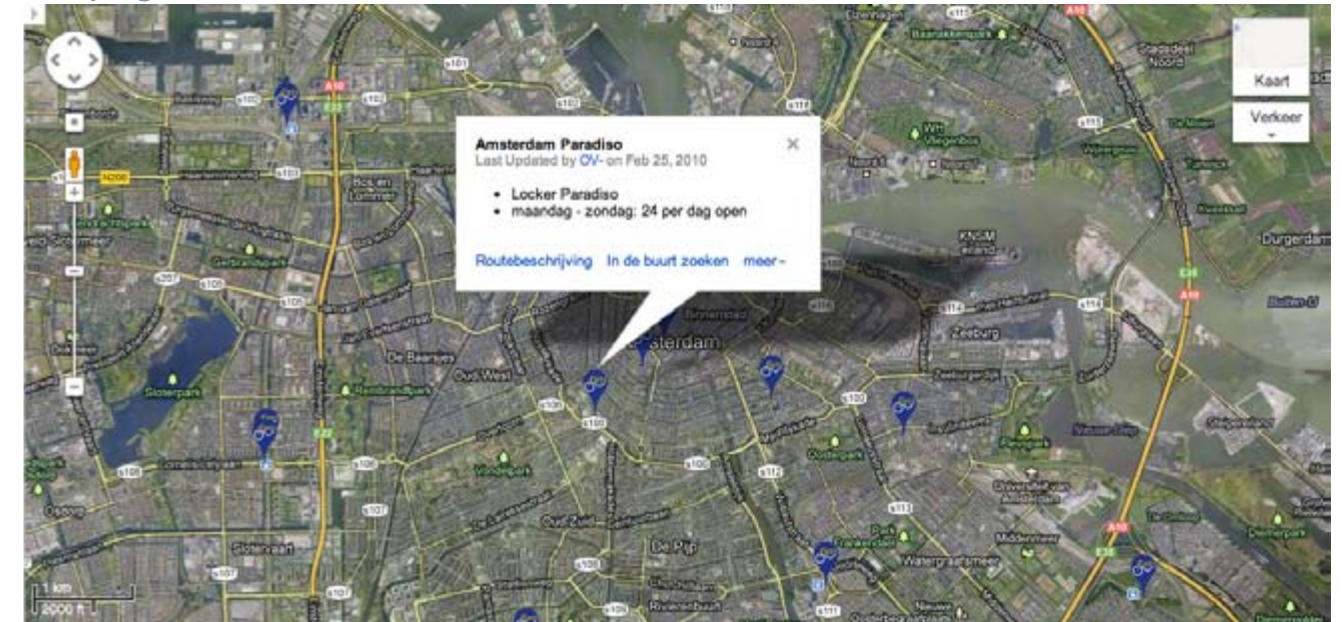
Railway stations/ Metro station



P & R



Camping sites/ attractions



2.6.3 The urban network

As it was explained earlier, regions define our lives. Our job opportunities, culture interests and social networks are bigger than any neighbourhood or town. We need a system that accommodates all transport modes efficiently at the same time that it supports urbanism and quality urban transit throughout the region.

The new urban network (Figure 2.19) proposed by Calthorpe (2002) is diverse and complex, mixing different types of auto uses with transit, biking and walking. It sets up a new hierarchy of arterials and boulevards that allow for through traffic without always bypassing commercial centres, so that the road could reinforce access to walkable neighbourhoods, urban town centres, and transit without cutting them off from local pedestrian movement. 'This new network incorporates transit in a way that is affordable, appropriately placed, and inherent to the system. And finally it reserves freeway capacity for long trips while providing alternate means for daily work commutes and shopping trips.' (Calthorpe, 2002, p.2)

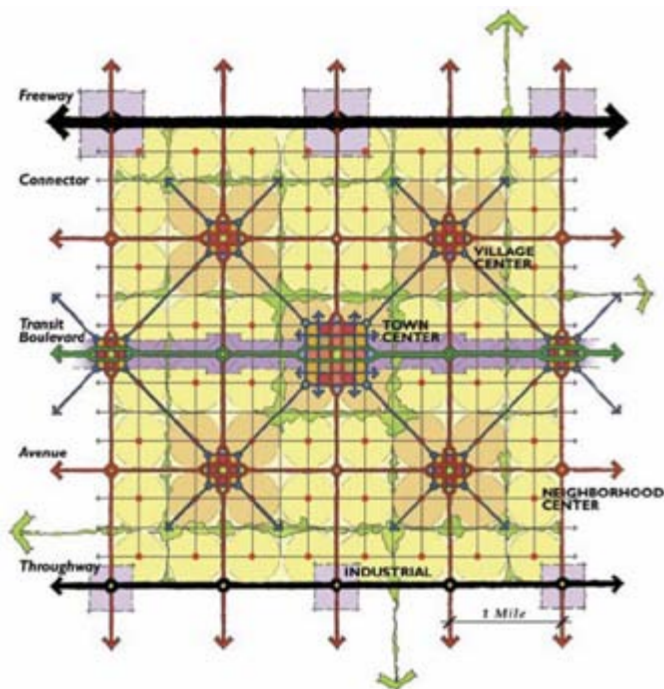


Figure 2.19 New urban network (Calthorpe, 2002)

In this urban network, four types of major roads were proposed to replace the standard arterial grid: Transit Boulevards, Throughways, Avenues and Connectors.

- Transit Boulevards combine semi-local auto trips with transit right-of-ways;
- Throughways are limited access roads for longer trips;
- Avenues lead to commercial destinations;
- Connectors provide for local circulation within and between neighbourhoods.

As Calthorpe (2002) describes, the Transit Boulevards are at the heart of this new network, they are multi-functional arterials designed to match the mixed-use urban development that they support. It would be lined with higher density development and would run through a 'Town Centre' approximately every four miles (Figure 2.20). The transit system running along the Boulevards and through the towns could be Light Rail, Streetcars, or Bus Rapid Transit (BRT). In contrast to the Boulevards, the Throughways take the role of our older highways, support truck and auto-oriented land-uses, such as low-density manufacturing, warehousing, and light industrial development.

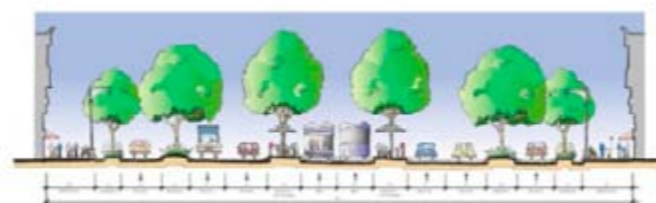


Figure 2.20 Transit Boulevard (Calthorpe, 2002)

In addition, there is another discussion about the distance between regional centres. Newman and Kenworthy (2006) established a Ped Shed model (Figure 2.21) to estimate the urban amenities that should be provided within a reasonable walking distance. Due to the travel behavior, two travel-time budgets were discussed and referred to two different types of centres: the local centre for 10 minutes of walking or the town centre for 30 minutes of walking. The Town Centre or Regional Centre is a place providing viable services for a region within a city.

'Thirty minutes covers the whole travel-time budget for those walking to urban services, and particularly jobs, within the Ped Shed.' (Newman & Kenworthy, 2006, P.43)

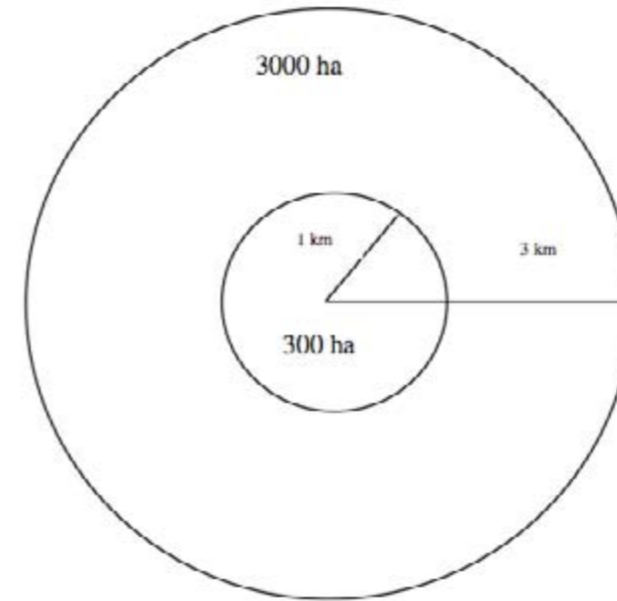


Figure 2.21 Ped Shed (Newman & Kenworthy, 2006)

In Calthorpe's model, the distances between 'Town Centres' or regional centres are four miles (6.5 km), which means for one regional centre, the radius of service distance is around 3.2 km. According to Newman and Kenworthy (2006), the distance between regional centres is 30 minutes of walking. If we assume the average walking speed is 5 km/h, then the radius of service distance for one regional centre should be 2.5 km. Considering the situation that on average 60% of all trips are shorter than 5 km, and 75% shorter than 10 km (Rooij, 2005), and the trends of electric bikes, we could set the threshold of distances between regional centres a little more flexible, 3 km is the ideal and 5 km is the maximum distance between two regional centres.

2.7 Model - Neighbourhood

'Each urban land use type has the appropriate scale and type of access.' (Calthorpe, 2002, p.4) Calthorpe (2002) explains in the urban network, the town centre should be pedestrian friendly as well as accessible to the Boulevard's through traffic and transit line. The villages are directly accessible by foot, bike, bus, or car from their surrounding neighbourhoods. Auto and truck oriented uses would be away from the transit and mix-use centres, and locate at the intersections of the Throughways. That is, there should be two transport networks, one is for the pedestrian-oriented, and another is for car-oriented (Figure 2.22); the first one is composed by town centres and Transit Boulevards, and the second one is made up of Throughways, industrial warehouses and other auto-oriented uses. Both of these transport networks are accessible from the villages and neighbourhoods, but the urban environment will give more priority for bikers and pedestrians than the drivers.

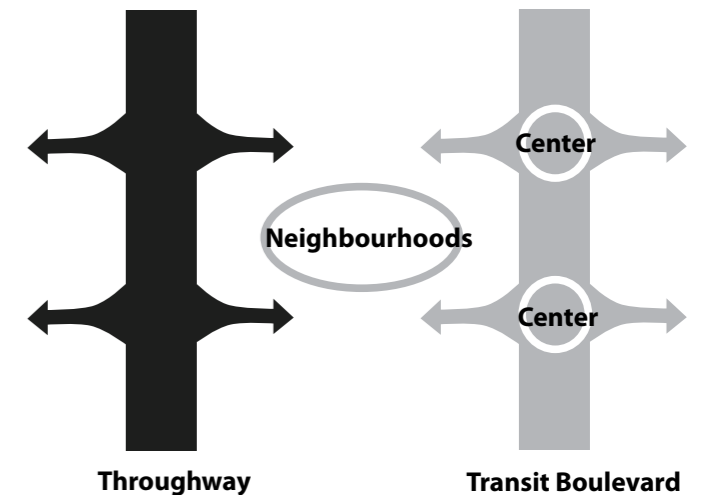


Figure 2.22 Transport networks

'As with any circulation system, the spacing and configuration of the Urban Network would bend to environmental constraints and existing development. In retrofitting areas, certain existing suburban arterials could be converted into Transit Boulevards. The Network would work with existing freeways but may represent an opportunity to replace freeway extensions with a combination of Transit Boulevards and Throughways.' (Calthorpe, 2002, p.5)

2.7.1 Transit areas

In 2009, APTA did a study about transit area of influence to adopt Calthorpe's TOD theory on neighbourhood scale. In their report (APTA, 2009), it defines the transit area of influence. Three types of spatial areas are covered by this standard (Figure 2.23):

- Core station area: The area around a transit stop or station within which land use and urban design features have a primary influence on transit ridership, and pedestrian access will generate a very significant portion of transit trips to and from the stop or station.
- Primary catchment area: The area within which land use and urban design features and the ease and directness of access to the stop or station both have a substantial impact transit ridership, and pedestrian access will generate a significant portion of transit trips to and from the stop or station.
- Secondary catchment area: The area around a transit stop or station within which ease and directness of access to the stop or station has the greatest influence on transit ridership, and within the majority of all trips utilizing the stop or station are generated. Within this area, bike, feeder transit, and auto are the primary access modes to and from the stop or station (APTA, 2009).

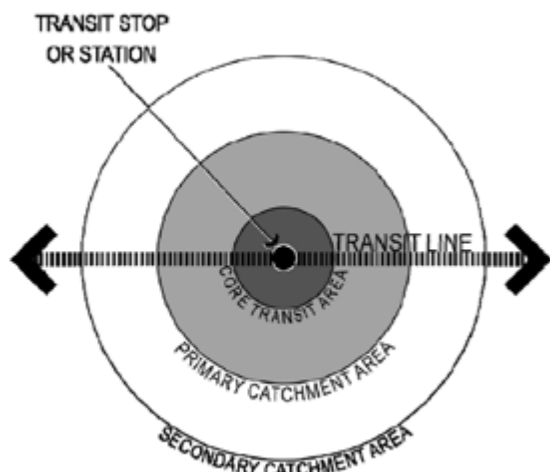


Figure 2.23 Basic concept of the concentric areas of influence (APTA, 2009)

In this report (APTA, 2009), it also recommends some practice responses for applying the transit area of influence to planning and implementation of development and infrastructure projects (Figure 2.24).

Application	Core Transit Area	Primary Catchment Area	Secondary Catchment Area
Planning focus	Station design and access planning.	Station-area land use and transportation network planning.	Community-wide transportation and land use planning.
Development parking policy	No required parking requirements or parking maximums applied to private developments and park-and-ride facilities.	Reduced parking requirements and "unbundling" of parking from development.	Parking management and shared parking arrangements.
Development density	Concentration of highest density development.	Density greater than the community average.	More compact development patterns than community average.
Ground floor uses	Active ground floor uses such as retail along pedestrian access routes and in immediate proximity to transit station or stop.	Focus active ground floor uses on primary pedestrian corridors.	Focus active ground floor uses along primary transportation routes and at key nodes.
Chiviotopen space	Human-scale active plazas that facilitate access to transit with elements that support intermodal activity.	Network of active and passive open spaces to meet community and transit access needs.	Network of large and small open spaces that link to regional open space system.
Street design	Highly walkable streets throughout the area with priority on pedestrian and mobility device access.	Focus on direct pedestrian, bicycle, and transit access routes with priority on pedestrian and mobility device access.	Focus on direct access routes with focus on bicycle and feeder transit access.

Figure 2.24 Implementation response applications (APTA, 2009)

2.7.2 Traditional Dutch city centre

On neighbourhood scale, the transit area is city centre as well: it combines the transit nodes and mix-use, and is dominated by walking but also could be accessed by other transport modes. 'A town centre contains a much larger quantity of retail along with higher density housing, major office development and a more extensive street system.' (Calthorpe, 2002, p.5) Traditional Dutch city centres have all these qualities and they all have similar traffic system (Figure 2.25). The city centres are surrounded by a ring road and within the ring road, the centres have narrow streets and parts of them are car-free zones. It provides quality spaces for pedestrians and bikers, and also stimulates retails and local business.

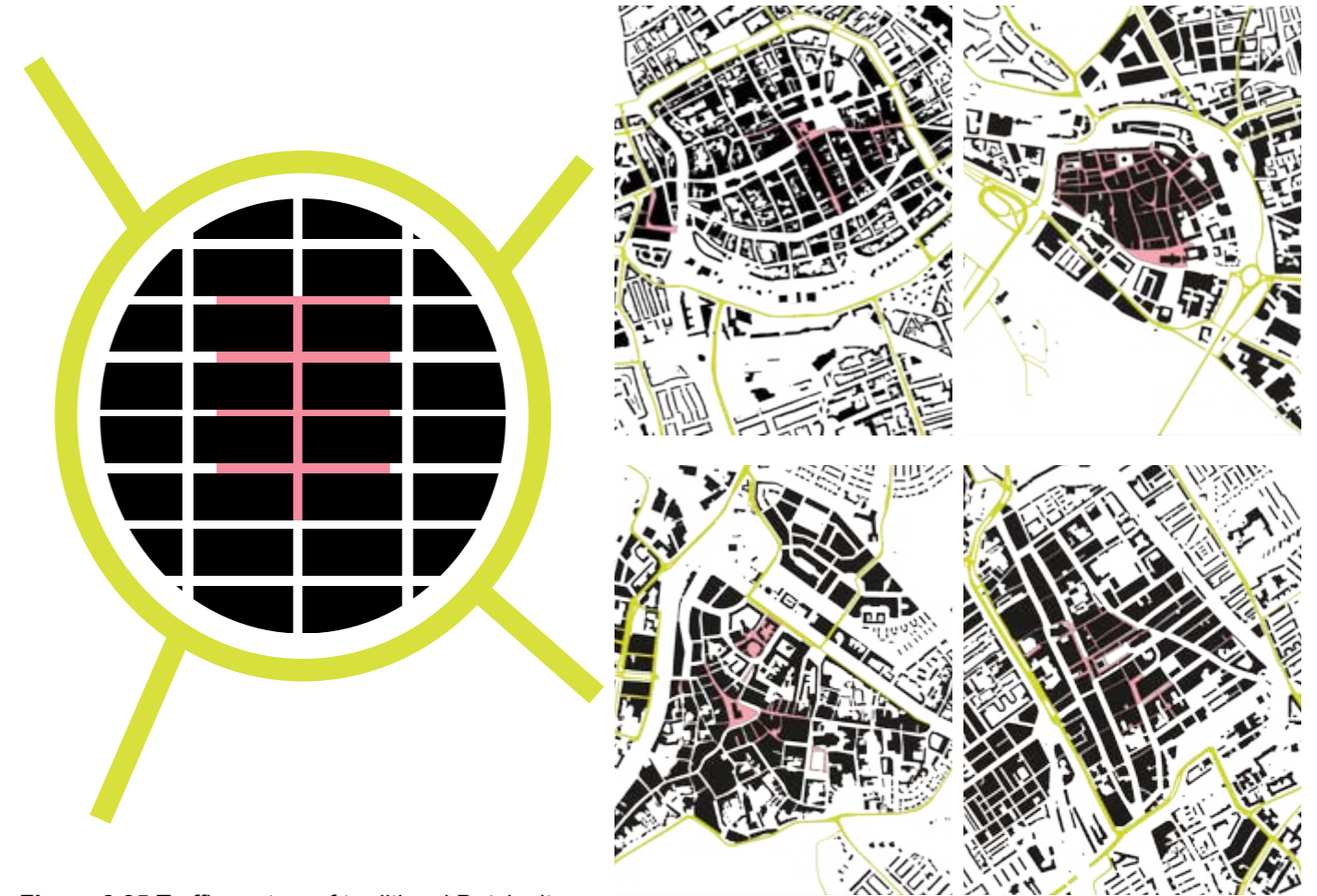


Figure 2.25 Traffic system of traditional Dutch city centres

The quality spaces of traditional Dutch city centres could not be simply copy and paste on the new Dutch city centres, but we still could learn a lot from them. First, the outer ring road and the parking lots on the edges of the centre prevent the unnecessary private cars driving into the central areas. Secondly, the narrow streets and quality public spaces persuades people to walk and cycle. Last but not least, then centres are well connected with public transport, surrounded by railway stations, bus stops, trams stops and metro stations.

2.7.3 City as the meeting place

'City space must be carefully designed to invite walking, cycling and staying encouraging people to join in the common life of the city.' (Gehl, 2006, p.8) As Gehl argued, within a few decades, the public space in the cities

has changed character and purpose, and the demands on quality city space have grown accordingly (Figure 2.26). The new roles for public space and public life are redefined in a situation where daily life for many people become more privatized. Meeting other people is no longer an automatic part of daily life, for we have more resources, more time and more space and, in fact, our direct meetings with other people can be few and far between. This situation is exactly where we need to consider when establishing good city spaces and developing opportunities for new city life.

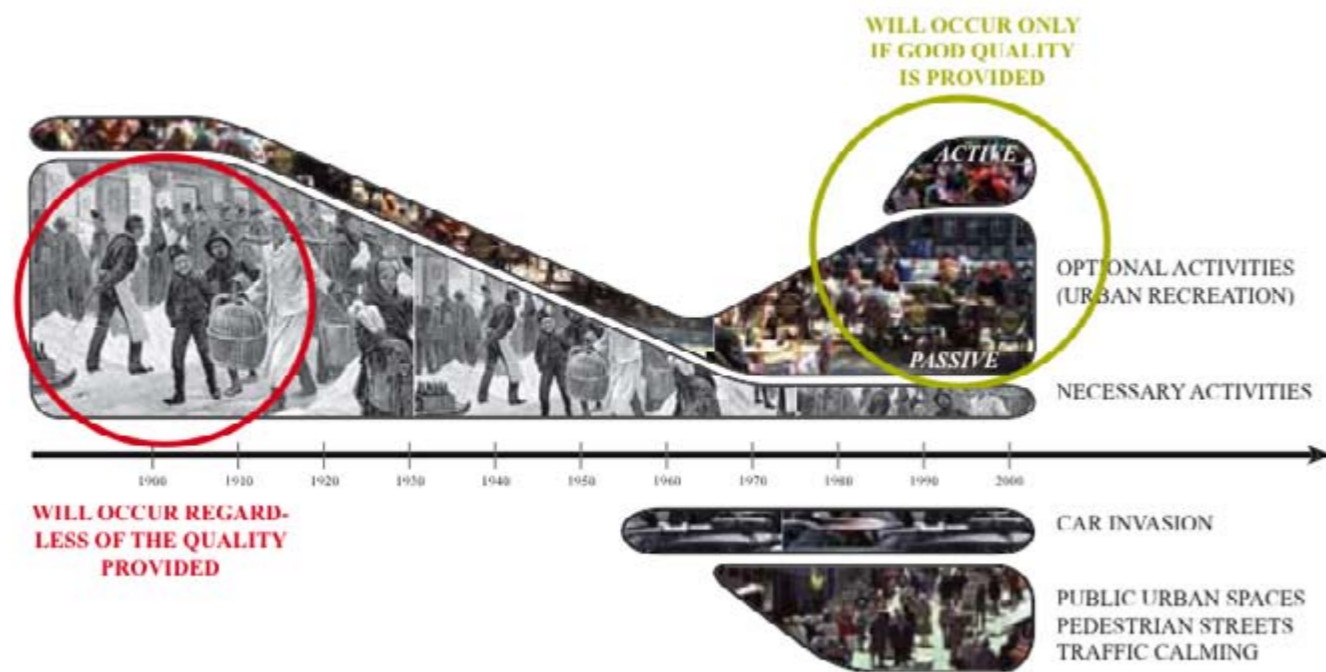


Figure 2.26 Demands on quality city space (Gehl, 2006)

City space is the medium for people's meetings with society and each other. 'Facilitating the meeting between people is the most important collective function of the city. New city life with its demands for good city space is a new guise for one of the most important function of city culture.' (Gehl, 2006, p.14)

2.7.4 City space quality criteria

Based on Gehl's research (Gehl, 2006), he set up 12 key quality criteria to ensure safe, comfortable and enjoyable city space for residents (Figure 2.27). After test on some selections of Copenhagen's city space in 2005, it proved that the city spaces meeting most quality requirements are also the most popular and well-visited sites in the city. Conversely, the city spaces that meet few or next to no quality criteria are those least utilized.

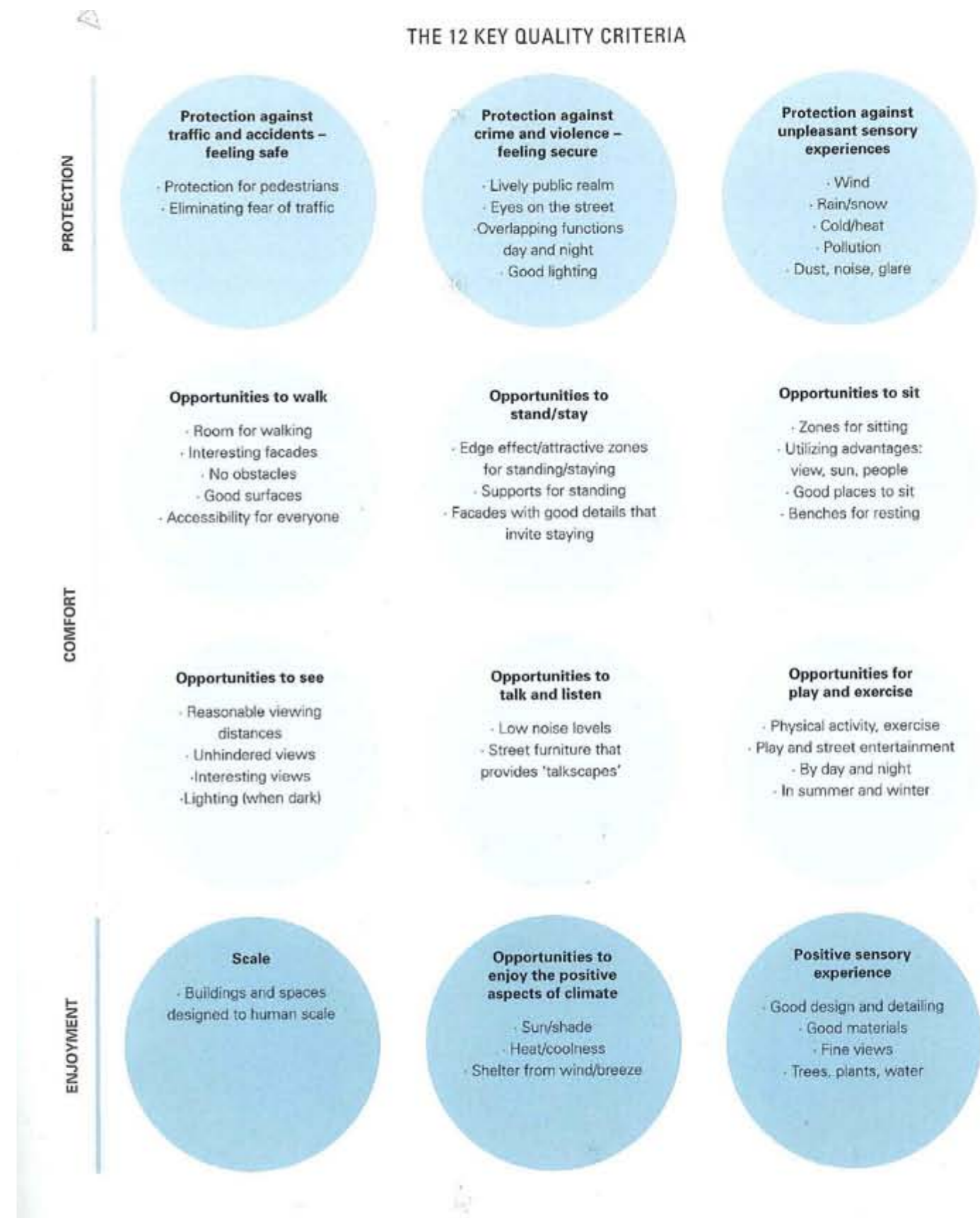


Figure 2.27 12 key quality criteria for city space (Gehl, 2006)

Protection

Protection expresses our need to be kept safe from accident, insecurity and discomfort. First, traffic is an import factor, and good conditions for pedestrian traffic must be provided by good city spaces. Secondly, crime prevention is to ensure a genuine sense of security when we move about the city. Dark, deserted spaces and streets often promote a feeling of insecurity. This is best achieved by the presence of diverse functions, so that there are lights in the windows and people nearby at all the time of night and day. The third factor deals with protection against uncomfortable sensory experiences such as unpleasant smells, pollution or adverse weather conditions.

Comport

Opportunities to participate in a variety of activities and experience the surroundings rest on how city space is designed to facilitate basic human activities under good conditions. People prefer to say at the edges or border zones with their backs well protected, so that designing the edges of public space is especially important to city life.

Enjoyment

It is vital to create city spaces on a human scale, with fine details, good materials and good street furniture. Good city space must provide opportunities to enjoy the positive aspects of the local climate, and should offer good experiences, fine views and interesting sensory impressions.

In Gehl's opinion (2006), the aim of these key quality criteria was to understand of how the relationship between cities and people works. These criteria could do more than evaluate the existing city spaces, but also could be guidance for new design works of city spaces.

2.8. Smart grid and parking facilities

In reality, we could not remove the private cars entirely, but we could improve the space and energy efficiency of the private cars by using automated robotic parking garages and connecting electric car charging with Smart Grid.

The automated robotic parking consumes less space than conventional parking lots, it promises the same amount of parking as offered by existing operations in 50% of the land area. And it operates easily for the customers, 'customers leave their car on an automated "lift", which then travels to the nearest available parking pod in the multi-story structure' (Arthur. D. Little, 2012, p.19), therefore, it offers more security and a lower in-garage accident rate, a lower rate of carbon emissions. When this technology applies to the urban design project, the multi-storey structure could combine with solar panel façade (Figure 2.28).

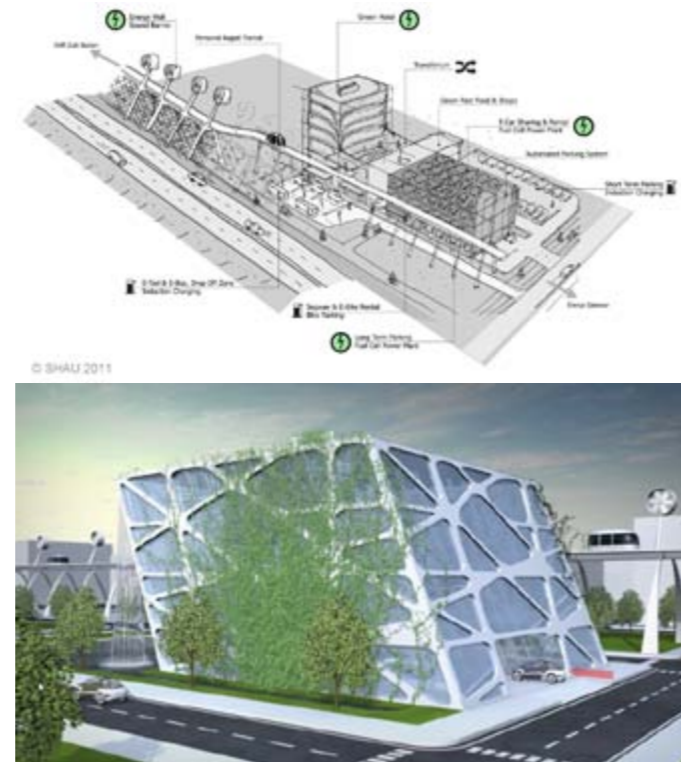


Figure 2.28 Automatic parking garage with solar panels (Wijk & Hellinga, 2012)

The automated robotic parking garages offer a solution for massive land requirement on parking facility. On the other hand, the plug-in electric vehicles and Smart Grid could improve the effectiveness of electricity. As figure 2.29 illustrates, the Smart Grid is envisioned as a complex framework to intelligently manage the energy generation, transmission and distribution (Smartgrid2030, 2012). In a study of economic impact of plug-in electric vehicles connected to a micro grid, they found that the economic impact is limited and case dependent (Momber et al, 2010). In their work, they use a California office building with plug-in electric vehicles connected as a model, and the result shows some economic benefit is created because of avoided demand charges and time-of-use rates. 'The strategy adopted by the office building is to avoid these high on-peak costs by using energy from the plug-in electric vehicle batteries in the afternoon hours.' (Momber et al, 2010, p.6) Nevertheless, it proves the possibility of using the batteries in plug-in electric vehicles as the buffer in a micro grid. The extra energy could be stored in the batteries during the off-peak hours and be collected during the peak hours, and the car owners could make benefit from the differences of the electricity price.

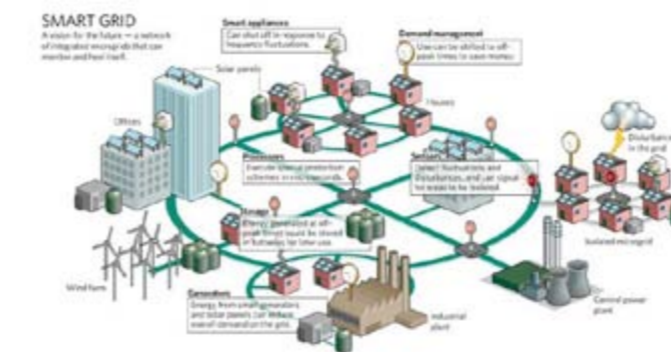


Figure 2.29 Smart Grid overview (Smartgrid2030, 2012)

In order to apply this idea into reality, a recent research (Quinn et al., 2009) introduces and compares two architectures of vehicle-to-grid (V2G) ancillary services, deterministic architecture and aggregative architecture (Figure 2.30), in availability, reliability and compensation for V2G ancillary services with the goal of directing the development of a near-term feasible and

economically viable V2G infrastructure. 'The results of these analyses show that a V2G architecture that aggregate vehicles can improve compatibility of V2G with current ancillary services system by improving the reliability of V2G ancillary services and meeting the minimum contractible power requirements.' (Quinn et al., 2009, p.9) The results of this work suggest that the aggregative architecture provides the concept of V2G provided ancillary services with a feasible pathway to near-term realization.

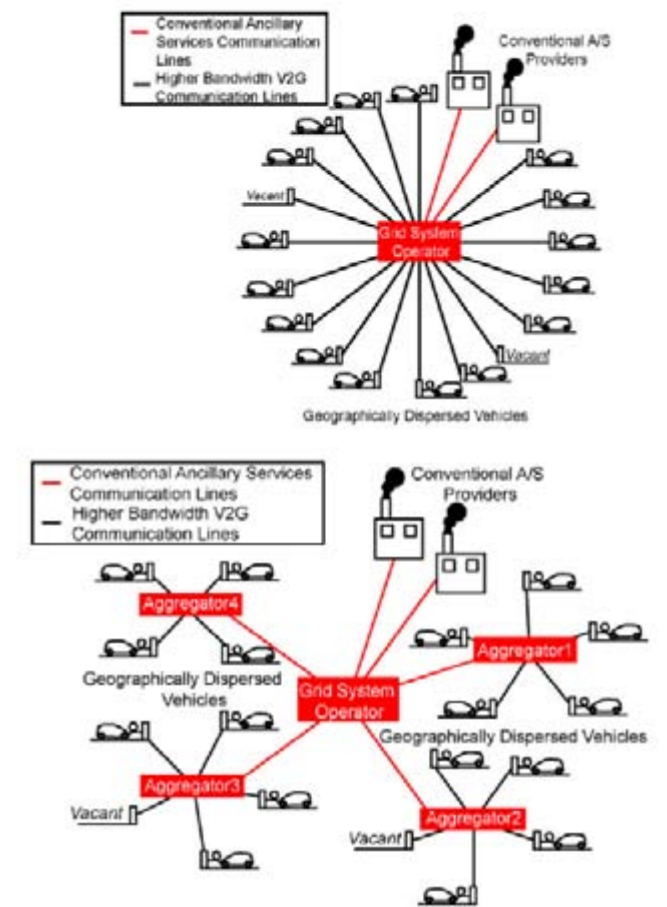


Figure 2.30 Deterministic architecture and aggregative architecture (Quinn et al., 2009)

As they (Quinn et al., 2009) describes, the aggregative architecture aggregates individual vehicles to make a single controllable power resource. 'In this aggregative architecture, an intermediary is inserted between the vehicles performing ancillary services and the grid system operator.' (Quinn et al., 2009, p.2) The aggregator can bid to perform ancillary services at anytime, which allows the individual vehicles engage and disengage from the aggregator as

Part 3 Site analyses

they arrive at and leave from charging stations.

In the Plug-in Hybrid Electric Vehicle Charging Infrastructure Review (Morrow et al., 2008), it explains three basic charge levels. The Level 1 method uses a standard 120 VAC, 15 amp (12 amp useable) or 20 amp (16 amp useable) branch circuit that is the lowest common voltage level found in both residential and commercial buildings in the United States. Level 2 is the primary method for a battery electric vehicle charger for both private and public facilities and specifies a 240-VAC, single-phase, 40-Amp branch circuit. Those two levels could be applied in residential garages, apartment complexes, commercial facilities and offices. Level 3 typically uses an off board charge system serviced by a 480-VAC, three-phase circuit. In practice, equipment sizes varied from 60 to 150 kW, and the battery electric vehicles achieved a 50% charge within 10 to 15 minutes. The Level 3 method or “Fast Charging” is for commercial and public applications and is intended to perform similar to a commercial gasoline service station.

Since the charging infrastructures have various charge levels and different types of buildings have various voltages, the voltage for industry or big public facilities is higher than the residential buildings and offices. The neighbourhoods could be divided into different zones based on the different voltages that the buildings require, and apply the aggregative architecture for vehicles-to-grid system. The residential and business zone with lower voltage and people are prone to stay over eight hours could have level 1 or 2 charge method. While the commercial or stadium with higher voltages could have level 2 or 3 charge method, which allow energy transferred within a short time.

To conclude, on neighbourhood scale, the transit area must combine with centre centres, providing civic amenities, a mixture of land use, public transit and quality urban spaces for walking, cycling and staying. Although the basic idea for neighbourhood design is pedestrian-

oriented, the central zone allows reaching by private electric cars. The electric cars must be parked in automated parking garages on the edge of the centre and be connected to the Smart Grid. At last, the diesel cars will not be prohibited entirely, but the plug-in hybrid electric car drivers do get more priority and benefits (Figure 2.31).

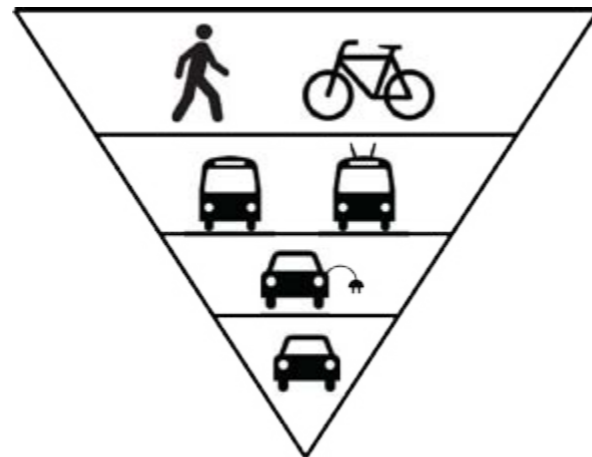


Figure 2.31 Priority of different transport modes on district level

3.1 Region

3.1.1 Transport

Arnhem-Nijmegen City Region plays an important role on (inter)national and regional transportation. Highway A12 is the vital connection between Randstad and Ruhr area, passing Arnhem-Nijmegen City Region on the north. Highway A15 is parallel to Highway A12, works as the second option for traveling between west and east in the Netherlands. Highway A50, starting from Eindhoven in the south and ending at Zwolle in the north, connects many major cities in the east Holland. There are two highways for cars crossing the river, one is Highway A50, and another is highway N325 and A325, which goes through the urban areas in Arnhem-Nijmegen City Region (Figure 3.1).

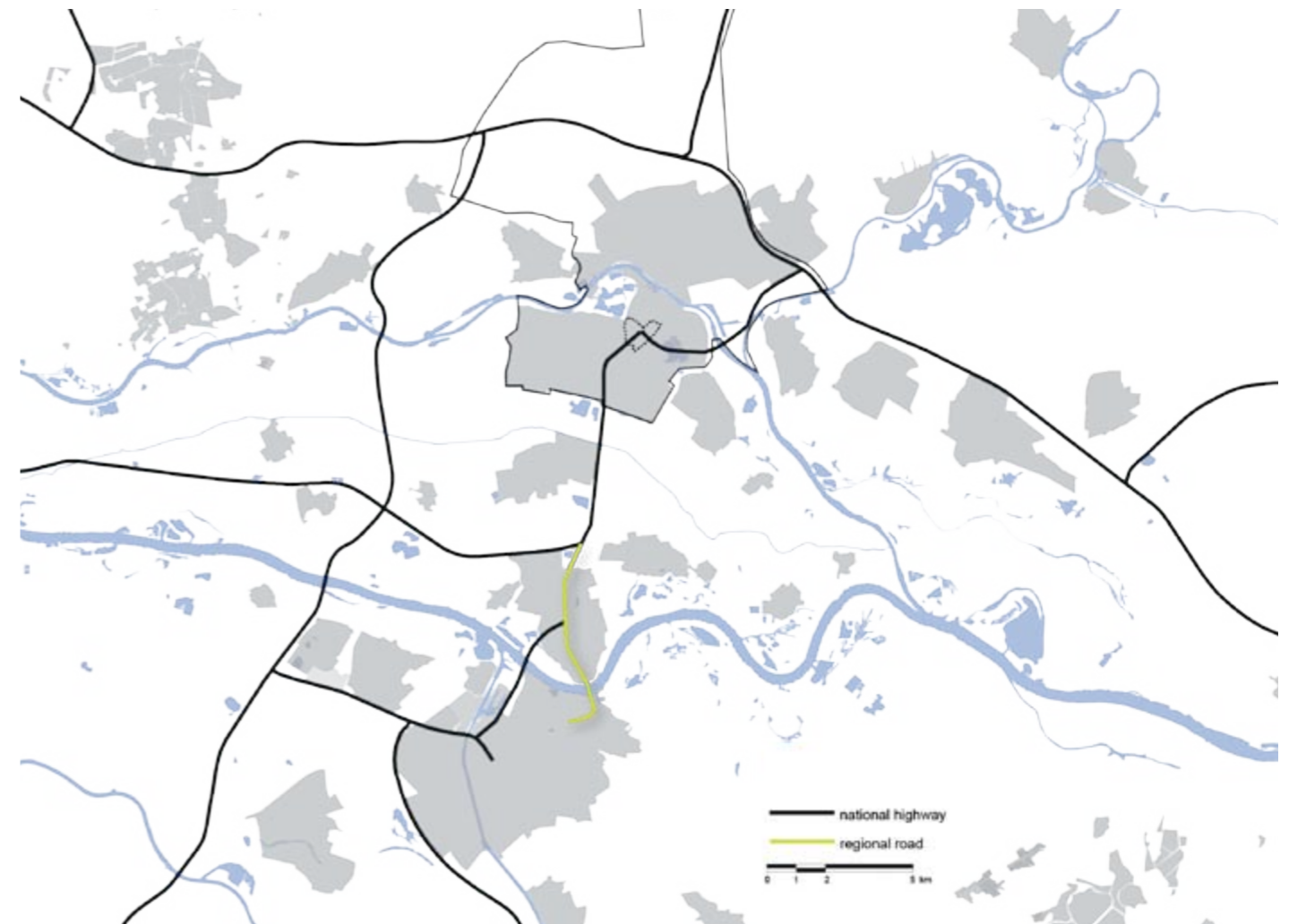


Figure 3.1 Arnhem-Nijmegen City Region transport network

Highway N325 and A325 is responsible for the regional transport. Figure 3.2 shows the traffic intensity on Highway N325 and A325 is much higher than other regional highways. Based on the CBS's data, more than 90% of all the cars are light vehicles and high intensity occurs on weekdays between 7 to 19 hours. It is clear that the individual cars travel between home and office are the main reason for high traffic intensity on Highway N325 and A325.

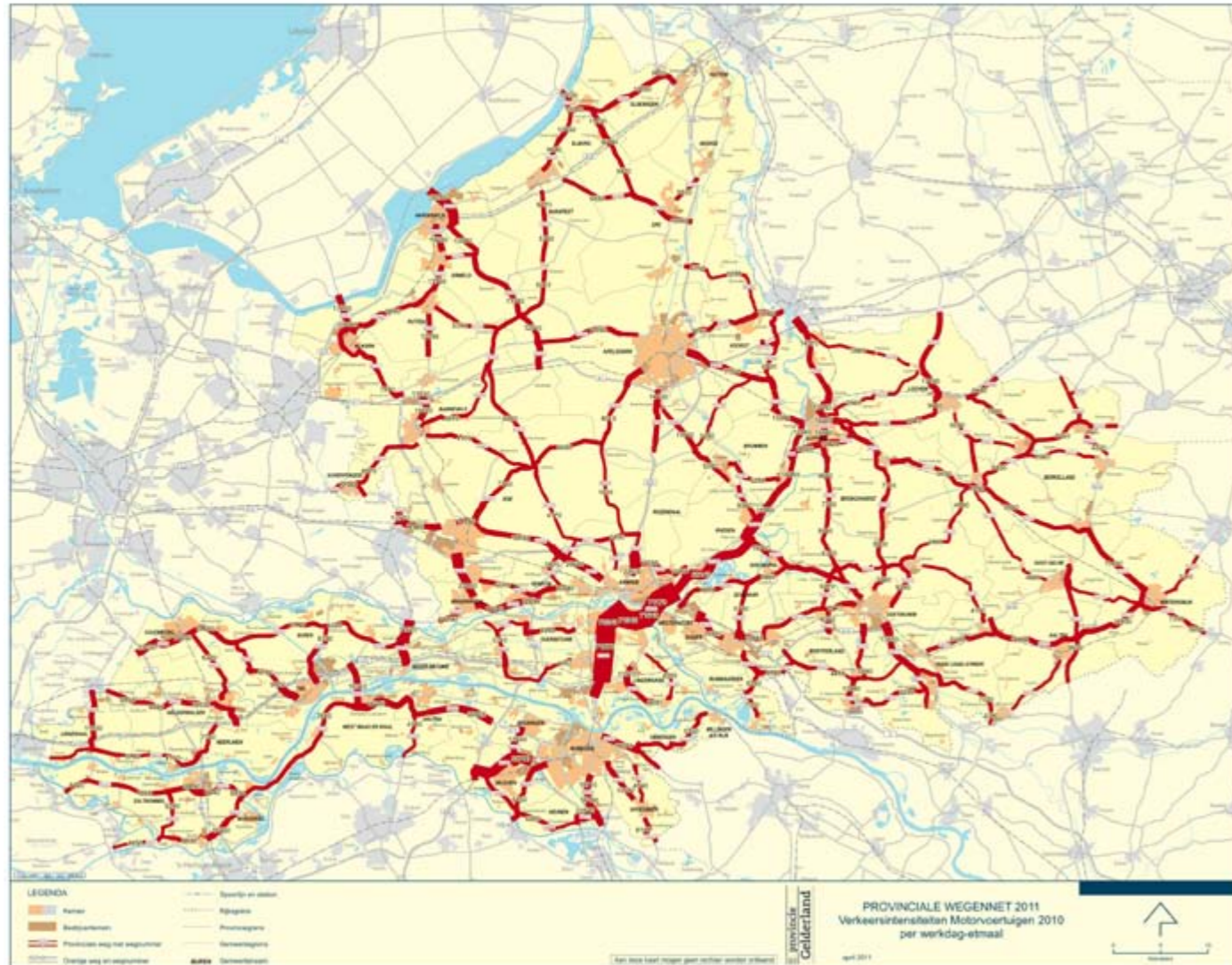


Figure 3.2 Traffic intensity in Arnhem-Nijmegen City Region (CBS, 2010)

Railway is the backbone of public transport in this region, for it connects all the main cities and towns. Urban developments follow the railway tracks expect in Arnhem south. Arnhem-zuid station is distance from the south centre (Figure 3.3).



Figure 3.3 Arnhem-Nijmegen City Region railway network

In the between area, the regional buses provide service for the small villages (Figure 3.4). For the travelers between Arnhem and Nijmegen, the best transport modes are the train and the private cars.



Figure 3.4 Arnhem-Nijmegen City Region bus network

3.1.2 Plan and vision

According to Koersnota Verstedelijking 2010 – 2020 met doorkijk tot 2040 (Stadsregio Arnhem Nijmegen, 2010), in the future, this city region will concrete on the developments of the two core cities and enhance the physical connections with those two (Figure 3.5).

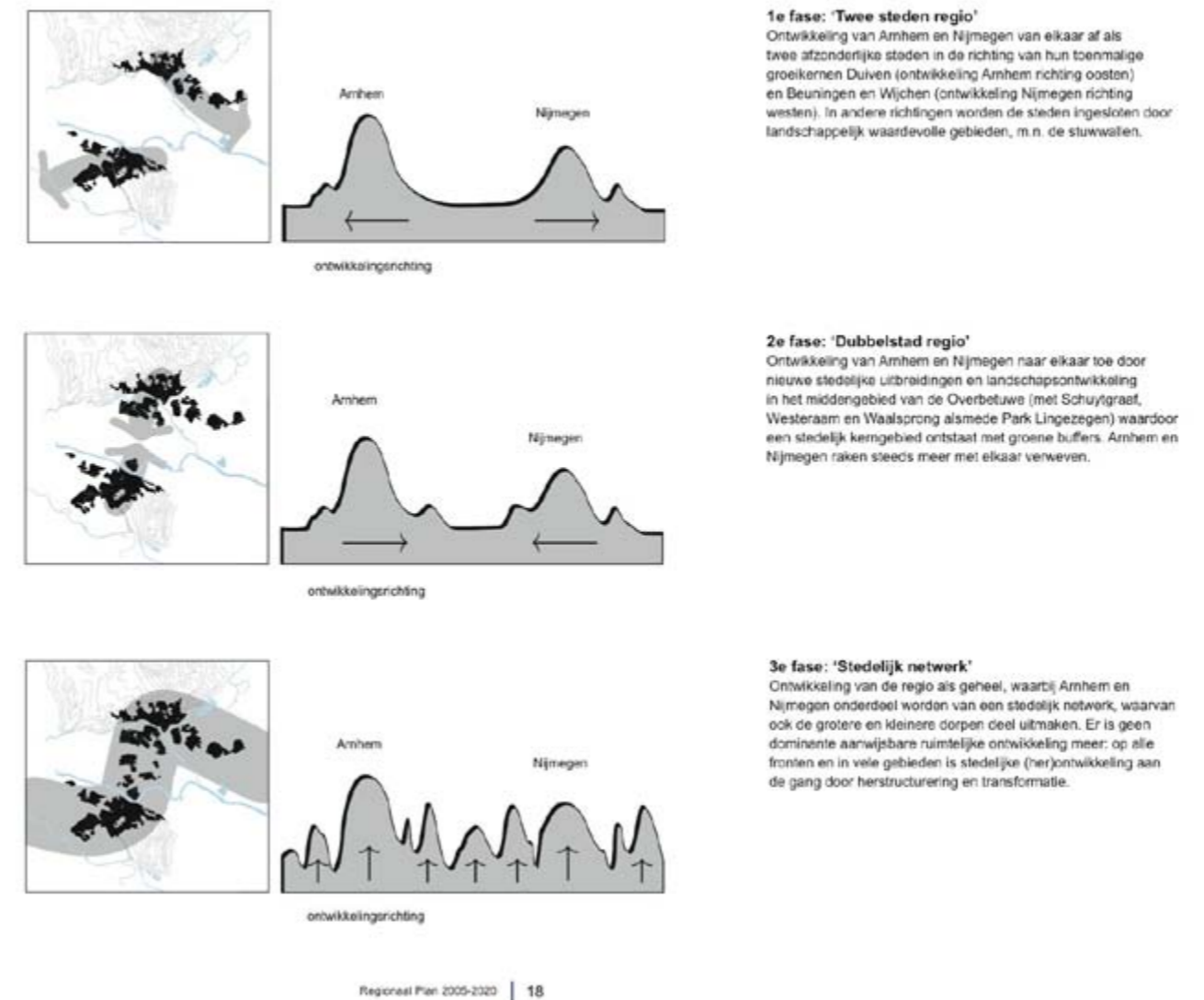


Figure 3.5 Regional plan in 2040 (Stadsregio Arnhem Nijmegen, 2010)

Also in this report (Stadsregio Arnhem Nijmegen, 2010), high quality public transport (HOV) will be introduced to Arnhem-Nijmegen City Region in the near future (Figure 3.6). The HOV system will have six axes; two of them will go north south, connecting Arnhem and Nijmegen city centres. Both of these lines will go detour to the small villages in the in-between areas. The detour in the villages will require extra stops, lower speed and longer travel time. That makes me doubt about the original intention of the HOV system, which is aiming to provide fast and reliable public transit service between Arnhem and Nijmegen.

Another action on regional transport network is the new extension of highway A15 (Stadsregio Arnhem Nijmegen, 2010), the third bridge over the river will be finished by 2040. As the report

says, the traffic volume between Randstad and Ruhr area will increase in the future and this action will split the traffic volume on Highway A50 and A12.

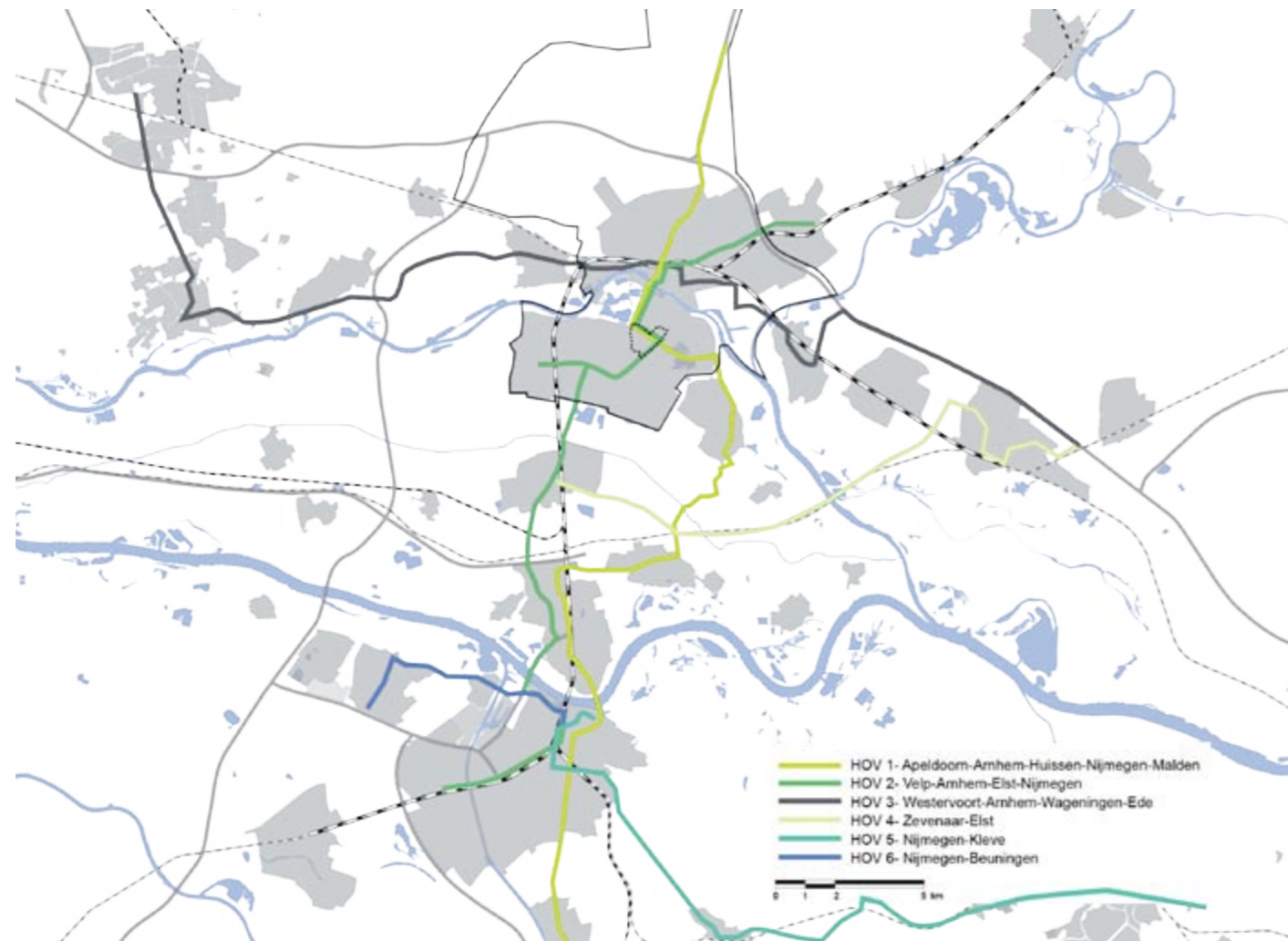


Figure 3.6 HOV network plan in 2040

3.1.3 Potential and problem

According to the plan (Stadsregio Arnhem Nijmegen, 2010), the goal of the extension of Highway A15 is to release the congestion on Highway A12. However, this action will bring more changes on this region rather than simply change the traffic intensity on certain highways. First, the changes will influence the land-use of the in-between area. The car-oriented land-use, warehouse, light industries, will be shifted to new locations, where is nearer to highways. Second, the existing car-oriented areas need to be regenerated to pedestrian-oriented. Meanwhile, the high-quality public transport (HOV) service is a clear sign that the public transit network in this region will be improved in the coming decades. These routes will have great impacts for the residents who live along the routes, and stimulate the development of existing local centres and regional centres with better accessibility.

3.2 City

3.2.1 Traffic and urban areas

Figure 3.7 illustrates Highway A325 is the only road going to the south. As it was mentioned in Section 3.1.1, Highway N325 and A325 have high traffic intensity and these two roads pass through Arnhem south centre. That is, on one hand, many cars pass by the south centre everyday, and on another hands, these two busy roads are physical barriers for pedestrians in the south centre.

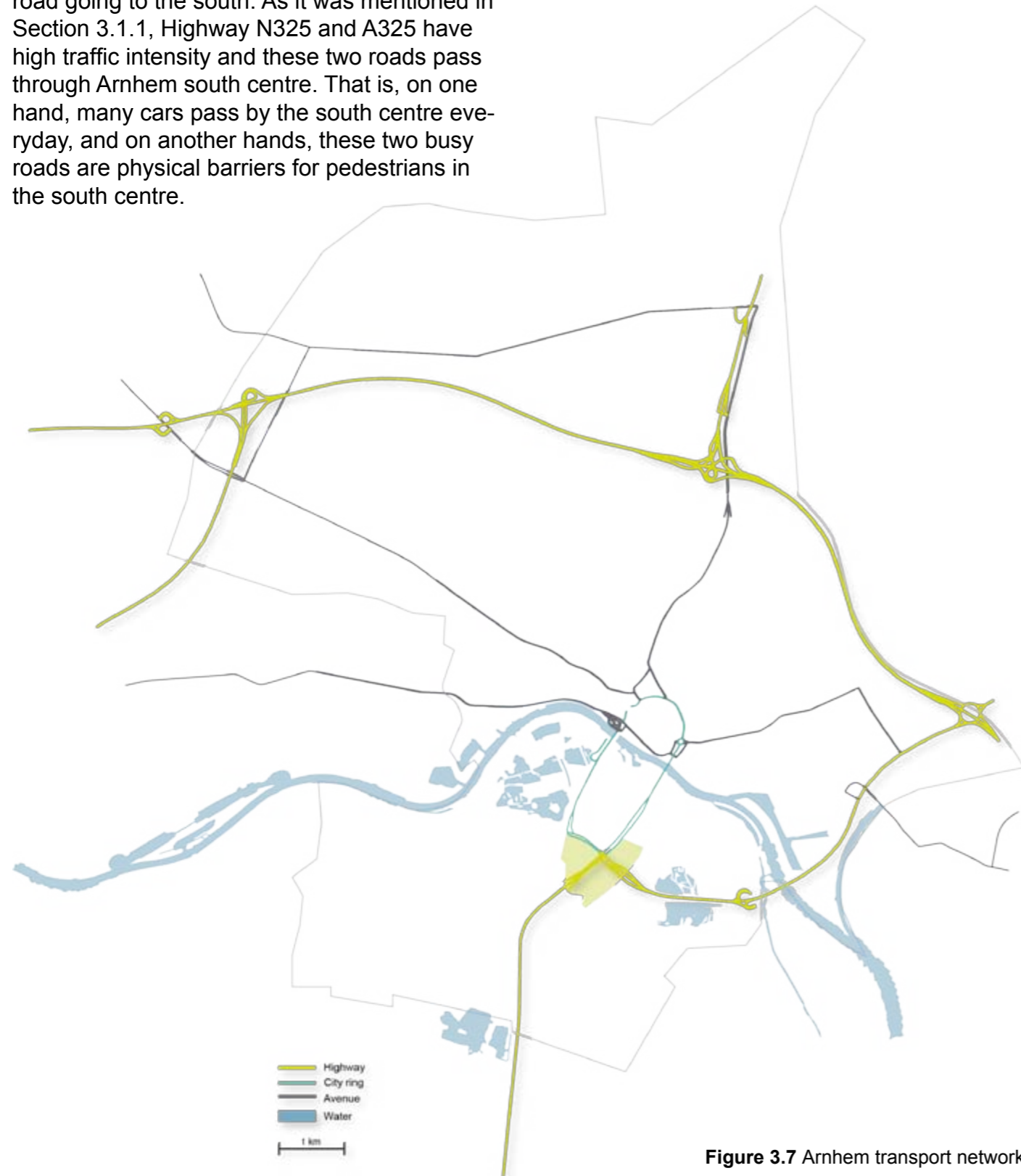


Figure 3.7 Arnhem transport network

Since the railway is very important on regional public transport network and the south centre zone is not close to railway stations, buses are needed for transferring people between the railway station and the centre (Figure 3.8).



Figure 3.8 Arnhem South bus network

In a study (Goudappel, 2009) of bike use in Arnhem and other middle-sized Dutch cities, the result shows (Figure 3.9) the bike use in Arnhem is comparably lower than other cities. The reasons are: first, the bridges between north and south banks are long and boring; second, the north bank is hilly and hard to cycle. The physical condition is hard to change, but according to the elevation map (Figure 3.10), most urban areas with high density are located in the flat areas (Figure 3.11), and moreover the new developments will be in the south bank around the Arnhem-zuid station. Hence, the second reason for low bike use in this study is not very critical.



Conclusies voor Arnhem

Modal Split verplaatsingen 2005 - 2007

	INTERN			EXTERN			TOTAAL			IE	
	auto	ov	fiets	auto	ov	fiets	auto	ov	fiets	intern	extern
Arnhem	55%	8%	37%	73%	18%	9%	65%	14%	21%	52%	48%
Almere	50%	11%	39%	75%	24%	1%	61%	16%	23%	65%	35%
Apeldoorn	52%	2%	46%	83%	10%	7%	62%	5%	33%	71%	29%
Dordrecht	51%	2%	47%	82%	10%	8%	65%	6%	29%	61%	39%
Enschede	55%	2%	43%	81%	10%	9%	65%	5%	30%	67%	33%
Groningen	31%	6%	63%	73%	20%	7%	52%	12%	36%	58%	42%
Haarlem	47%	4%	49%	69%	16%	15%	60%	11%	29%	48%	52%
s-Hertogenbosch	57%	2%	41%	82%	13%	5%	70%	8%	22%	55%	45%
Maastricht	49%	7%	44%	80%	14%	6%	62%	10%	28%	64%	36%
Nijmegen	44%	4%	52%	74%	16%	10%	59%	10%	31%	56%	44%
Utrecht	42%	9%	49%	64%	30%	6%	55%	21%	24%	48%	52%
Zwolle	38%	2%	60%	78%	17%	5%	57%	9%	34%	58%	42%

Positieve score ■
 Matige score ■

Figure 3.9 Modal Split verplaatsingen 2005-2007 (Goudappel, 2009)

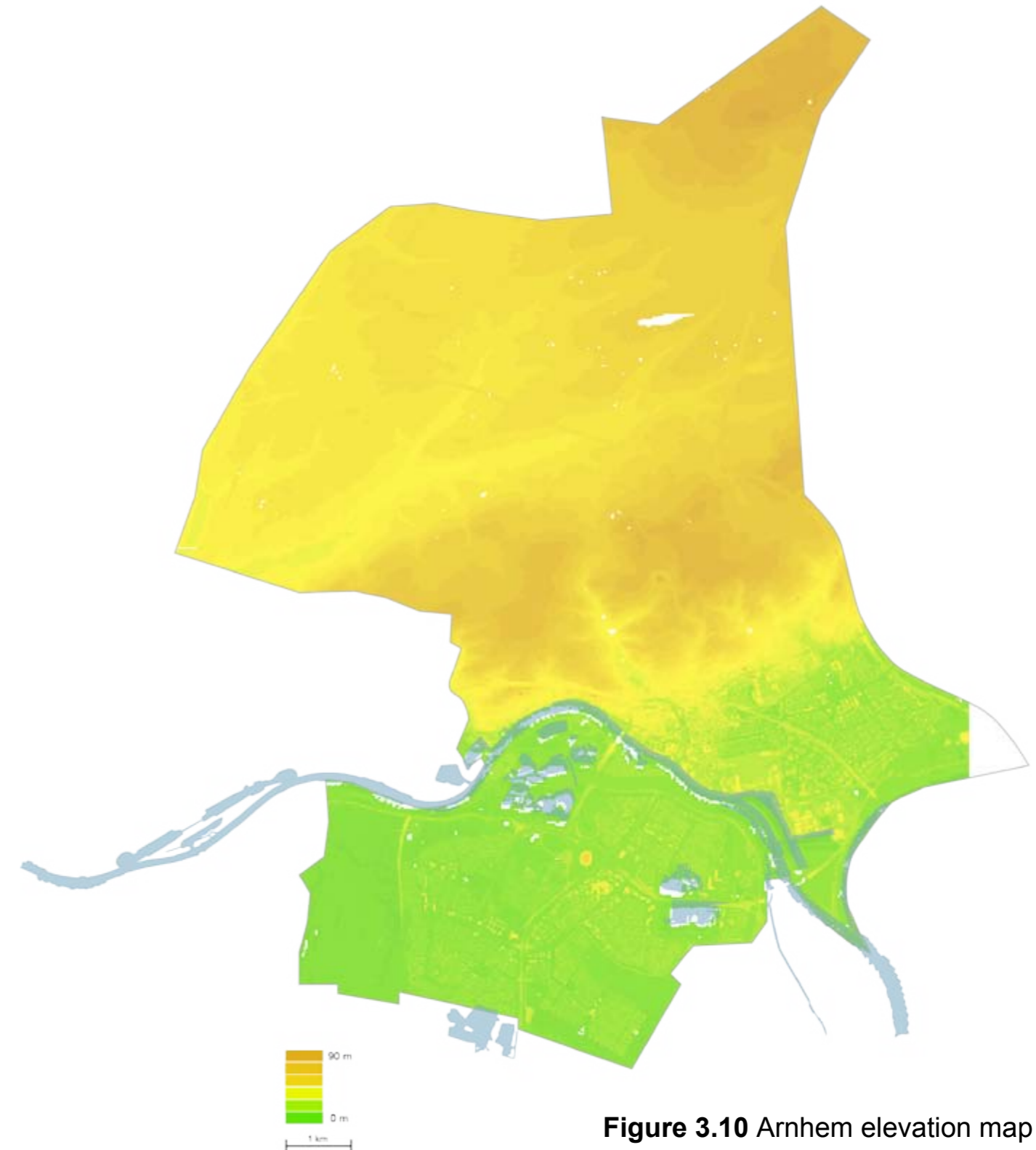


Figure 3.10 Arnhem elevation map

3.2.2 Potential and problem

The most obvious feature of transport behaviour in Arnhem is the comparably low percentage of bike usage among other middle-sized Dutch cities, partly owing to the invincible geographic features. Another problem in Arnhem is the long distance between the south centre and Arnhem Zuid railway station. The long distance makes the train not the best transport mode for the residents in Arnhem south, but the cars. Since the south centre serves half of the whole population of Arnhem, sometimes even the people of the whole region, it explains the requirements of wide streets and huge parking lots around Arnhem south centre.

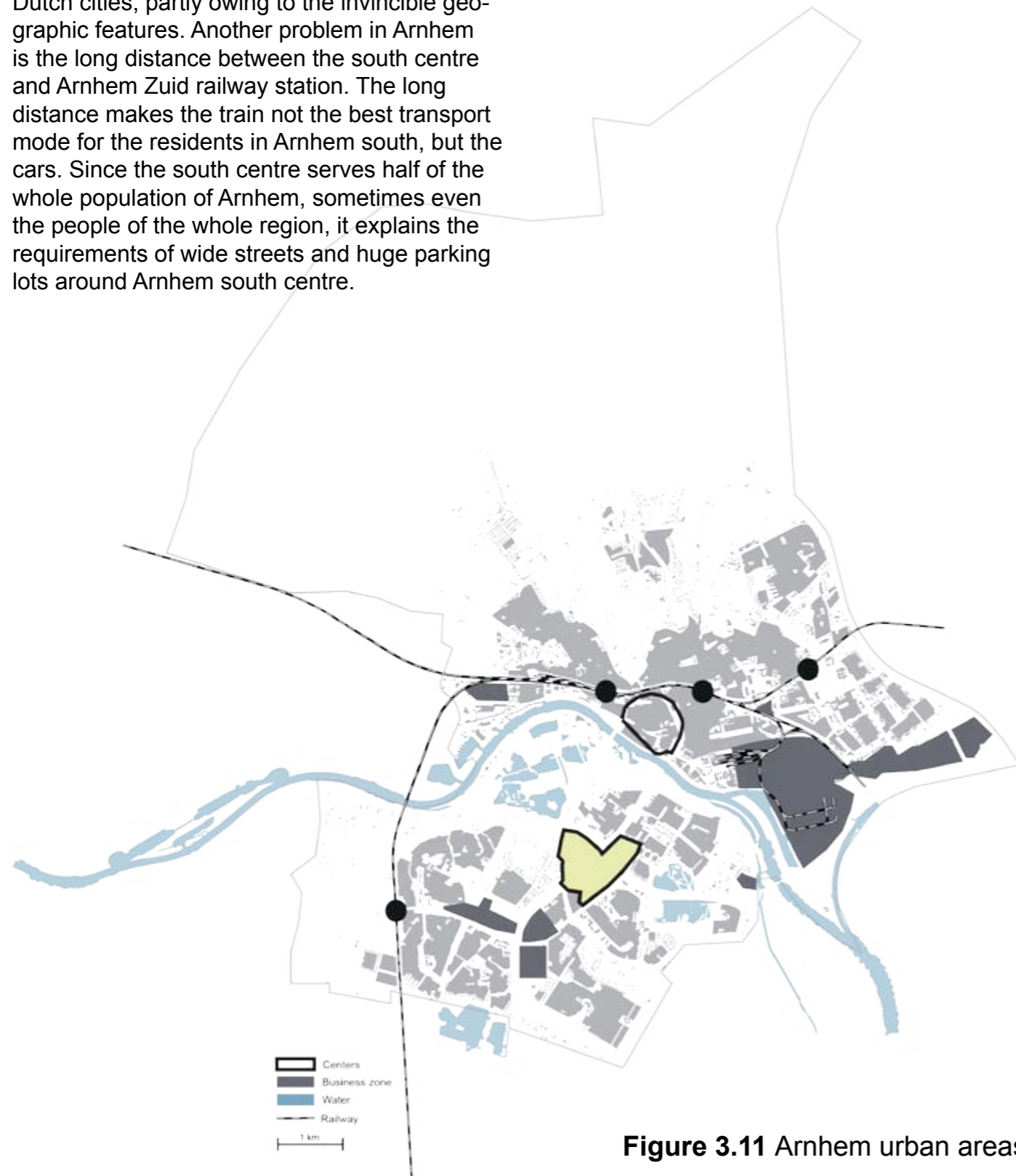


Figure 3.11 Arnhem urban areas

3.3 District

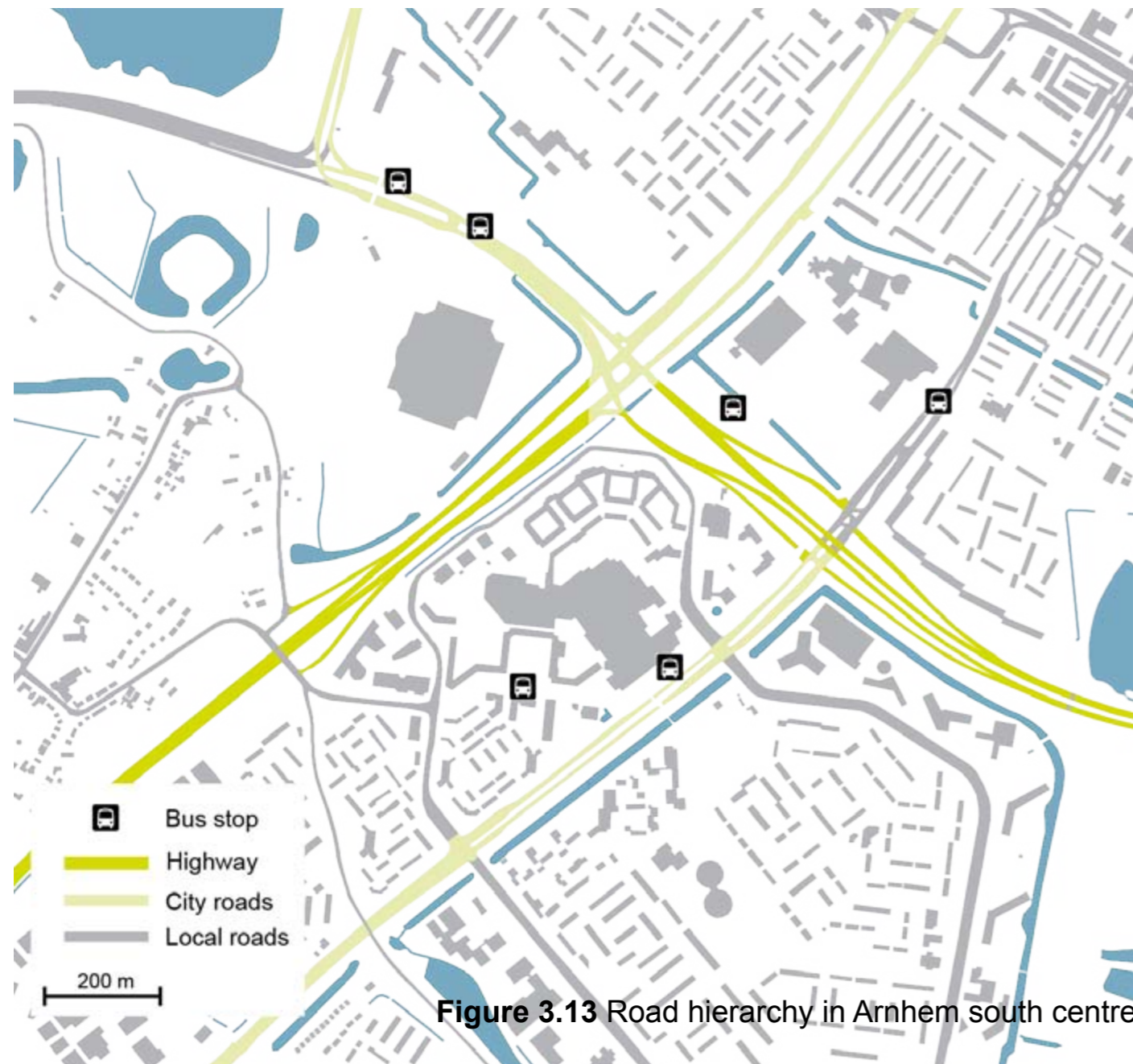
The project is focus on Arnhem south centre, which is dominated by three main public buildings, GelreDome stadium, Kronenburg shopping mall and Rijnhal. Those buildings together with other apartments and office buildings form Arnhem south centre (Figure 3.12).



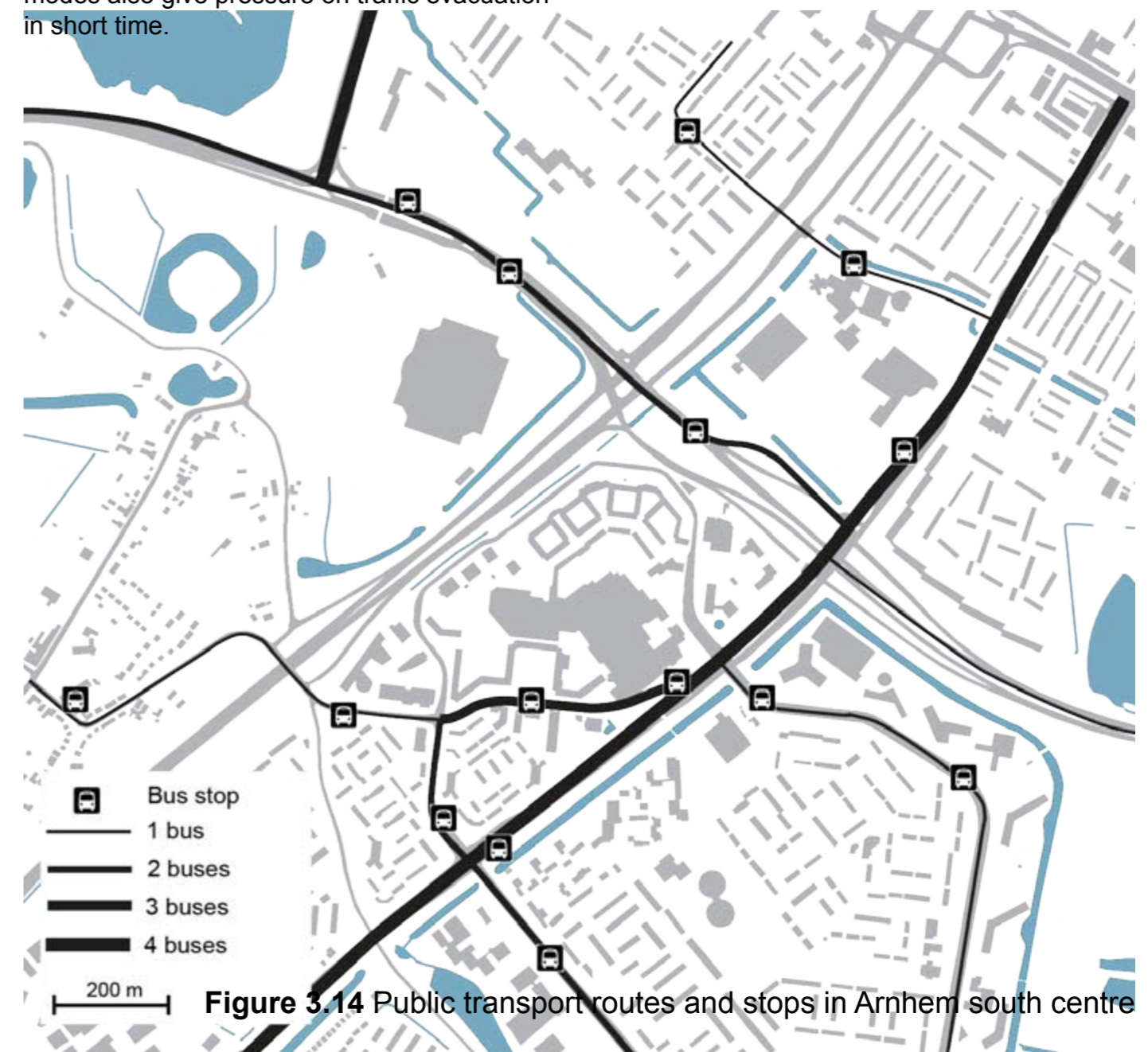
Figure 3.12 Site location

3.3.1 Traffic

Highways and city ring roads meet at the intersection (Figure 3.13). Due to the high traffic intensity, the roads are quite wide and do not allow pedestrian crossing the roads on the ground level. Tunnels and bridges are the spatial connections in this area.



Arnhem south centre is distance from the nearest railway station, buses is essential for the visitors traveling between railway stations and the south centre. Buses are operated on the local roads and stops near the main entrances of the three buildings. Bus hub is in the front of the shopping mall (Figure 3.14). Although the three public buildings have several entrances, but the visitors coming by public transport do not have much choices, thanks to the bus stops and building entrances limit the walking routes for the pedestrians. In addition, the fixed walking routes and lack of alternative transport modes also give pressure on traffic evacuation in short time.



Otherwise, people would come to the south centre by their own cars. Unlike the pedestrians, this area is convenient for the car drivers. There are plenty of parking lots (Figure 3.15), and the shopping mall, the stadium are branding themselves with the ample parking spaces. It persuades more private cars entering the centre area and increases the traffic intensity during the peak hours in this area and even in the whole region.

Hence, the alternate transport modes are needed in this centre zone. A regional public transit service could fill up the gap between the railway station and the centre, so that the visitors could come here with less transition. Meanwhile, the roads and the parking lots need to be organized, in order to reduce the private cars use in the centre.

3.3.2 Land use

The three leisure buildings are surrounded by amount of apartments, houses and some ofices (Figure 3.16). As the centre in the south bank, this area would hold big events indoor and outdoor. At this moment, the outdoor quality public spaces are needed and after that, the outdoor activities could be introduced to the south bank residents.

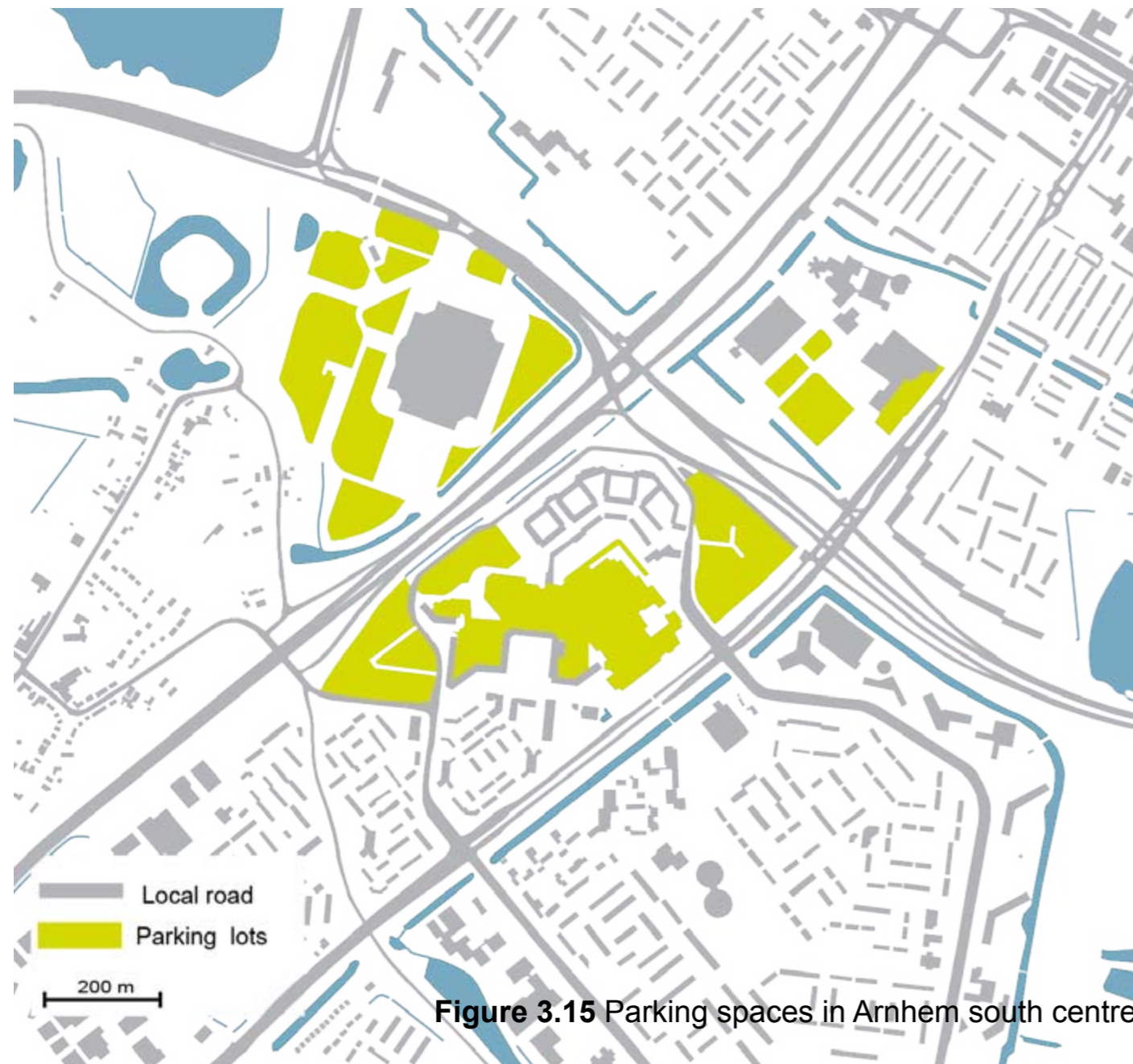


Figure 3.15 Parking spaces in Arnhem south centre

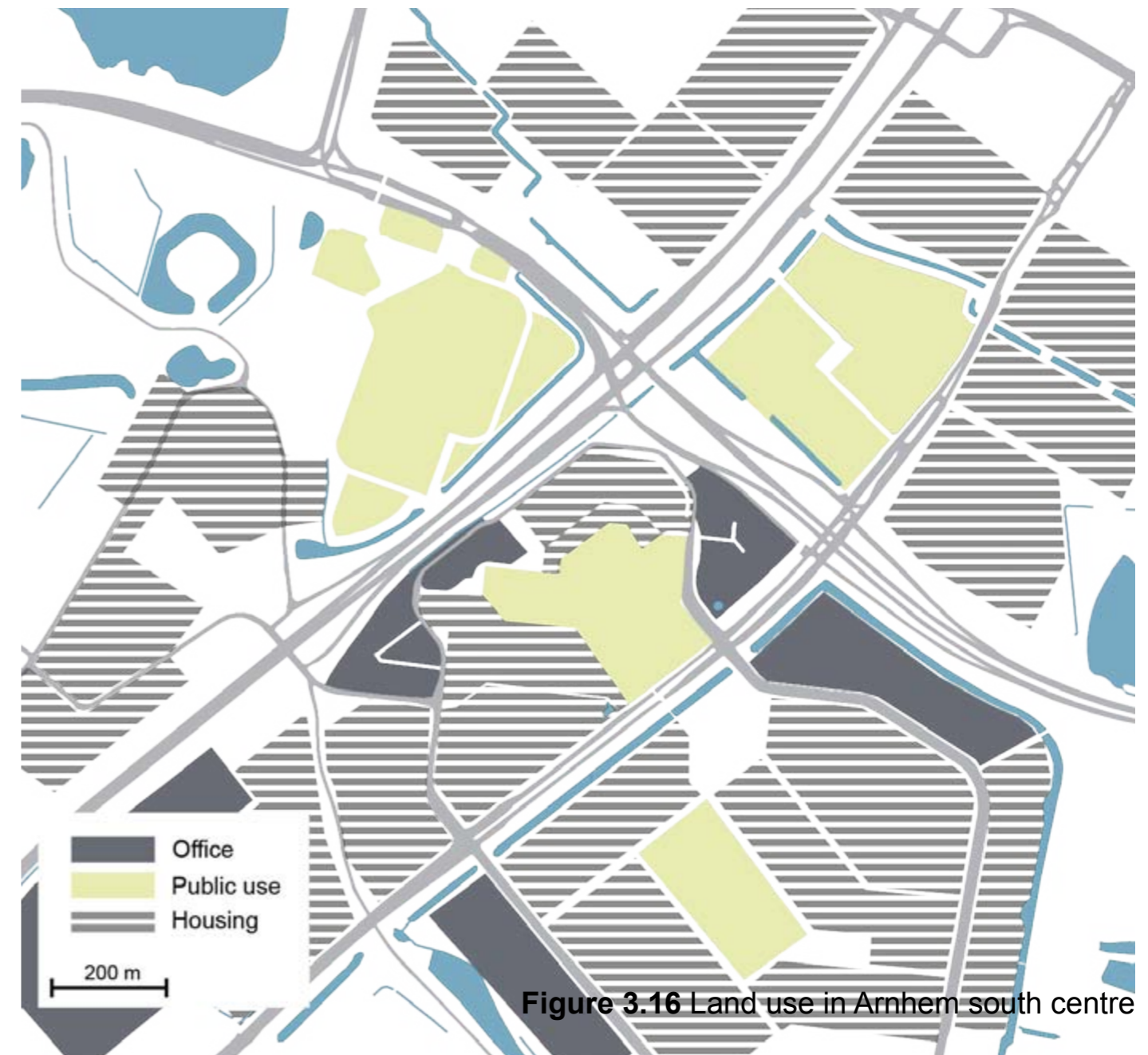


Figure 3.16 Land use in Arnhem south centre

The three leisure buildings have different service scale (Figure 3.17), along with different open hours (Figure 3.18) and function. The most important is the three buildings are lack of spatial connection. The tunnel is the only thing they have in common, but it is definitely not a meeting place (Figure 3.19).

Visitors coming to here with single purpose: to shop or to watch the football game. The ideal situation is that the visitors could have multi-purpose when they come to the centre, such as go shopping and then go dining, or go to the stadium and then go to the bars. Thus, the visitors would spend more hours in Arnhem south centre, and the peak hours could be flattened and more opportunities for local business.

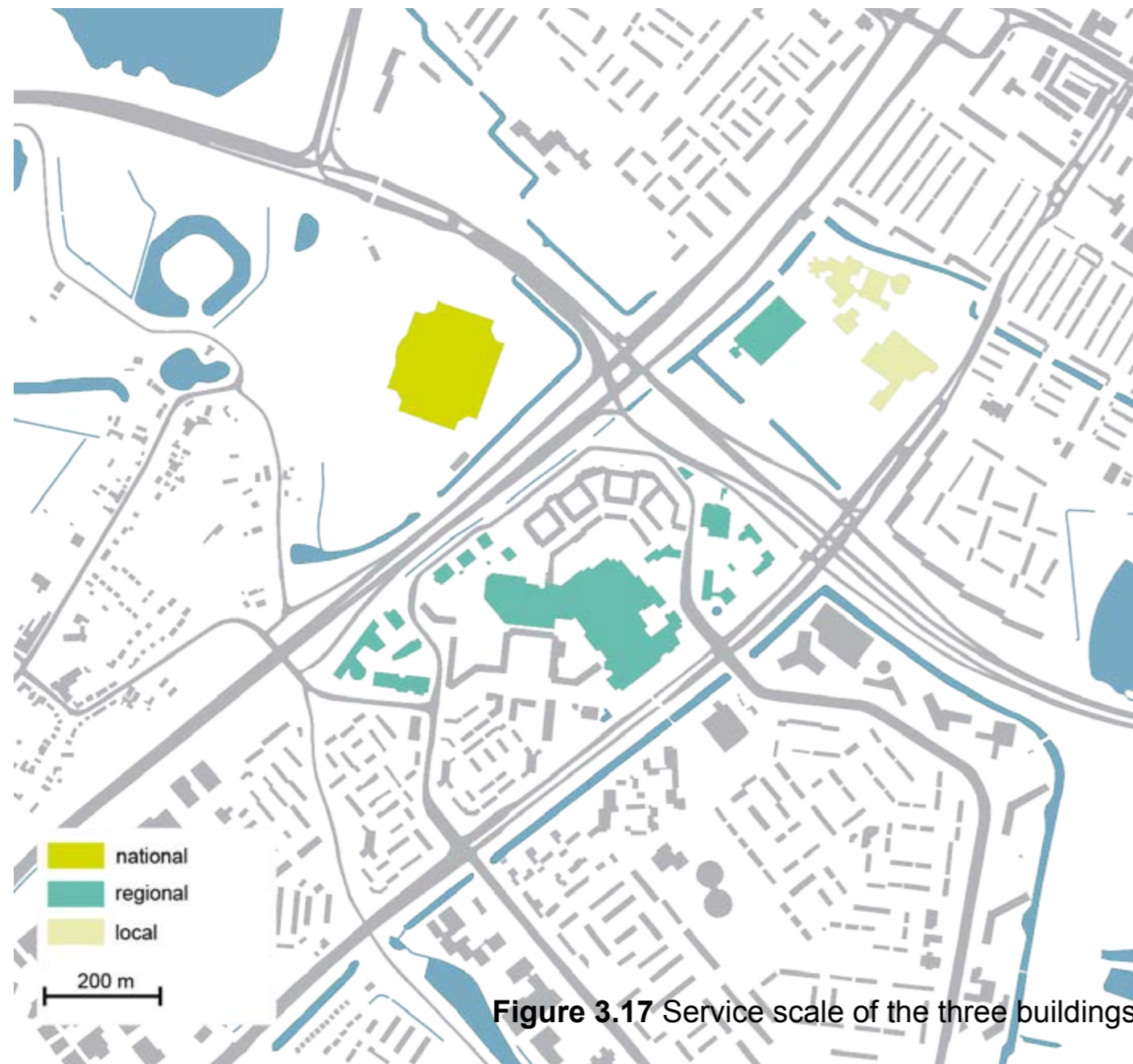


Figure 3.17 Service scale of the three buildings

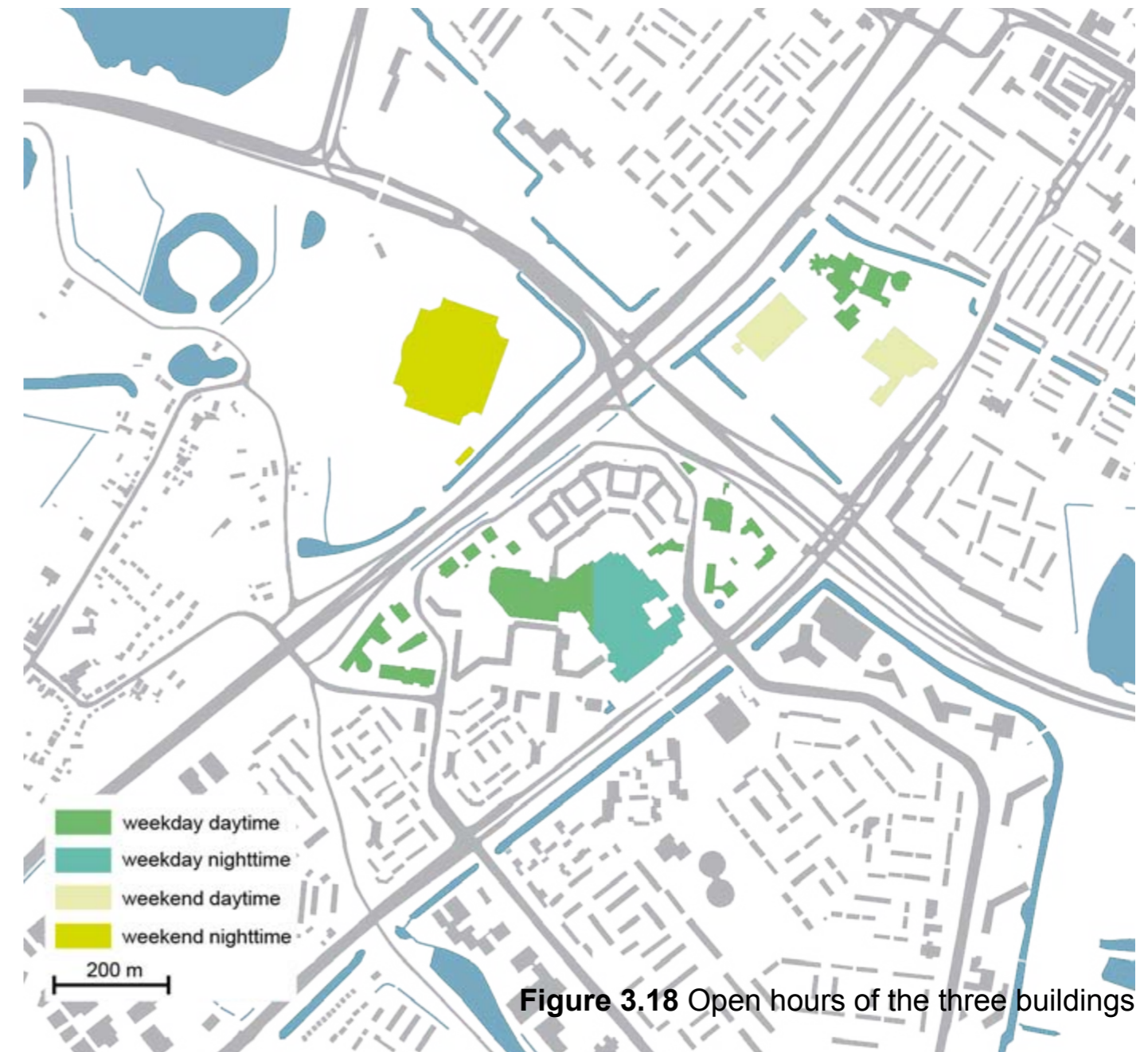


Figure 3.18 Open hours of the three buildings

Tunnels

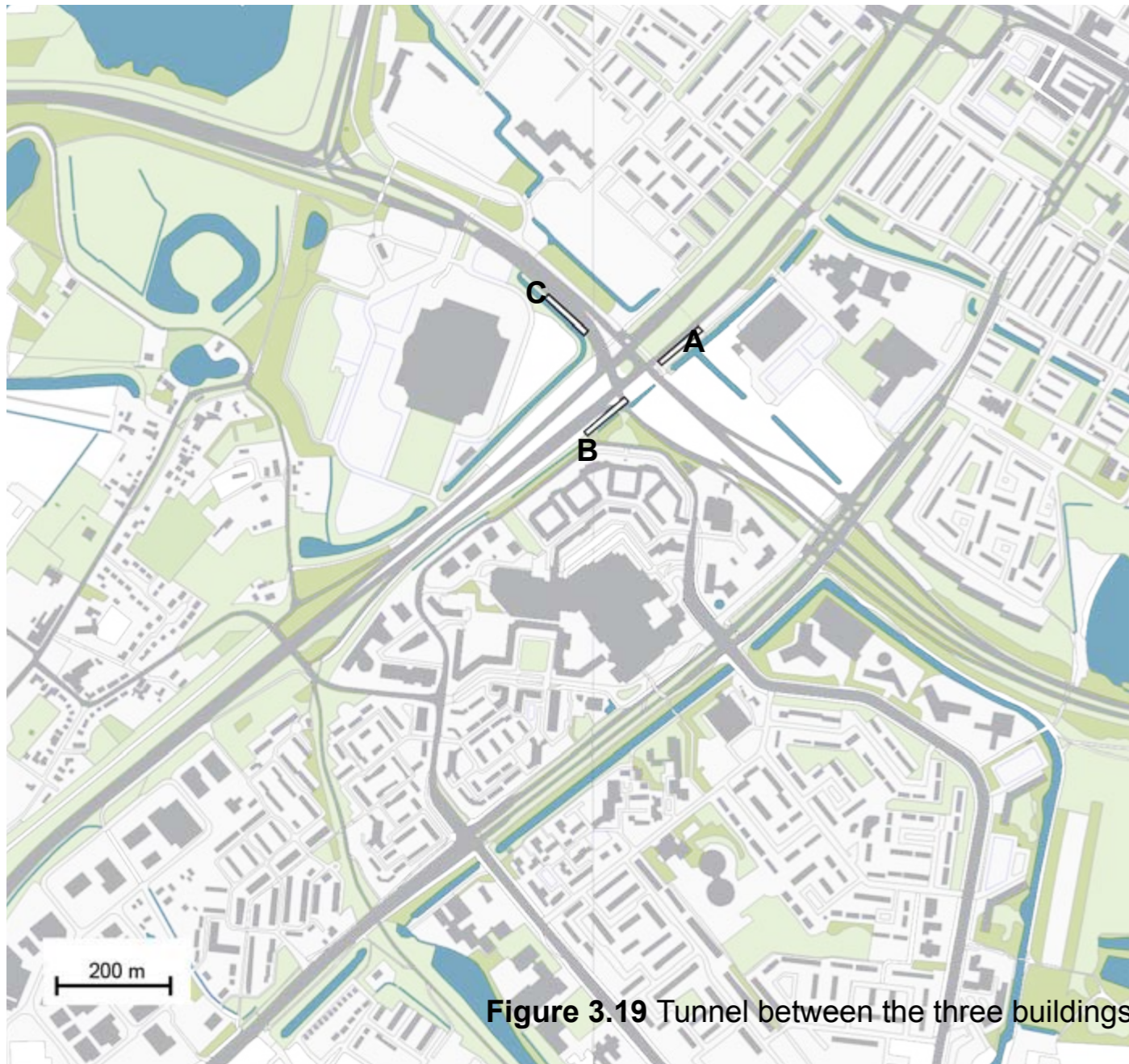


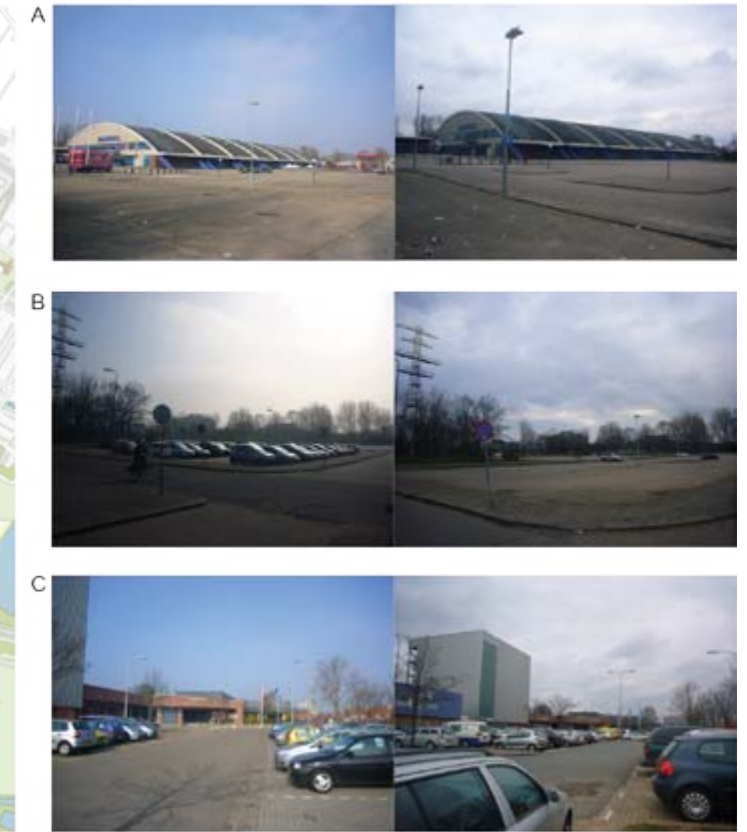
Figure 3.19 Tunnel between the three buildings

Parking lots in peak hours and off-peak hours



Friday afternoon

Sunday afternoon

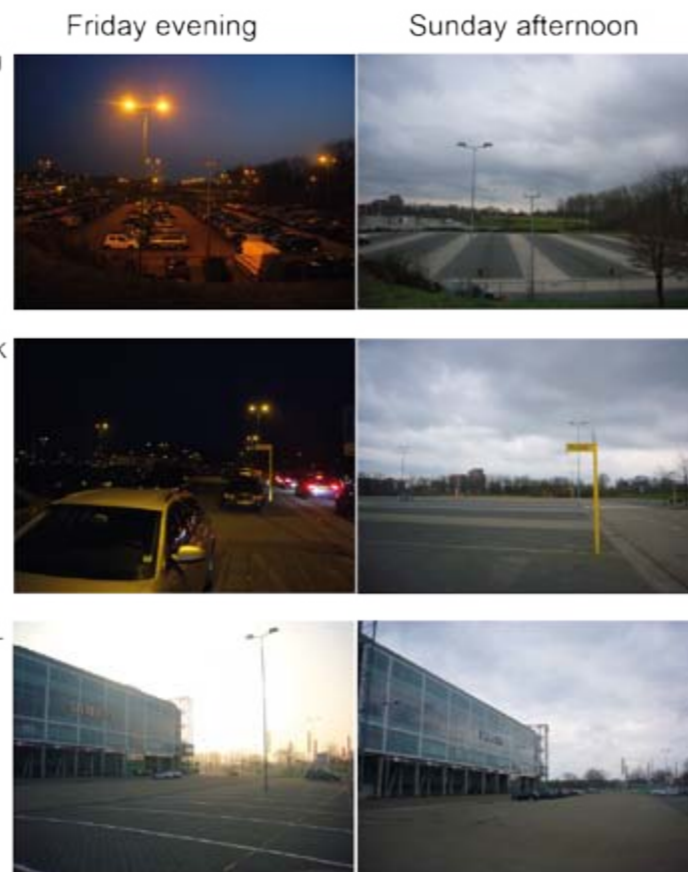


Friday afternoon

Sunday afternoon



Part 4 Design



3.3.3 Potential and problem

Three public buildings compose the centre zone in Arnhem south bank: the GelreDome Stadium, the Rijnhal and the Kronenburg shopping mall. These three leisure buildings are located at the intersection of the Highway A325-N325 and the city ring, and surrounded by numbers of parking spaces. Owing to the importance of its location and its economic and social impacts, the south centre has the potential to be a vibrant city centre with quality spaces and public transport service. The urban spaces need to be pedestrian-oriented. Various quality public spaces, not the huge parking lots, should be set next to the buildings. The street should allow pedestrians crossing instead of force them to use the tunnel.

4.1 Region

4.1.1 Strategy

On the regional scale, the aim is to promote the public transport and reduce the private car use in urban areas. By adopting the new urban network theory, Highway A15, A12 and A50 will work as the Throughways, take responsible for freight transport, while the new Transit Boulevard will be introduced to this region with high-quality public transport going through the town centres. The future developments will be transit-oriented developments, focusing on the town centres along the Transit Boulevard.

4.1.2 Suitable transport modes: Train, HOV and PHEVs

Two main collective passenger transport modes on regional scale are train and high-quality public transport (HOV). Since the future developments will be settled around the railway stations, the aim of HOV service is to connect the areas with the large transport demands but not close to the railway stations, such as the university, certain business zones and Arnhem south centre. Therefore, the HOV should be fast and flexible, but not follow the same routes as the railway tracks. Comparing the Light Rail Transit (LRT) with Bus Rapid Transit (BRT) system, they share the similar speed and serve similar spatial level. Although the LRT has advantage on low pollution gas emission, the low investment and the flexibility of the BRT system are overwhelmed.

The individual transport is also considered in the project. The Plug-in Hybrid electric Vehicles (PHEVs) are an ideal replacement for light duty diesel cars, for it produces less noise and pollution. The charging facilities, like the gas stations for the diesel cars, could be located in the town centres, combining with the parking garages around commercial buildings. In order to make sure the travel distance between two charging for PHEVs is shorter than 30 km, the distance between two town centres would be 20-30 km in Arnhem-Nijmegen City Region.

4.1.3 New Traffic network and plans

The new extension of Highway A15 to A12 is aiming at improve the (inter)national road transport. It will release the burden on Highway A50 and A12 and reduce the bypass cars on Highway A325 and N325. In the regional plan, Highway A325 will be downgrade to secondary connection and it will allow regional buses driving on it. The maximum speed will be lower to 60 km/h, and it will have more exits to the local roads (Figure 4.1).

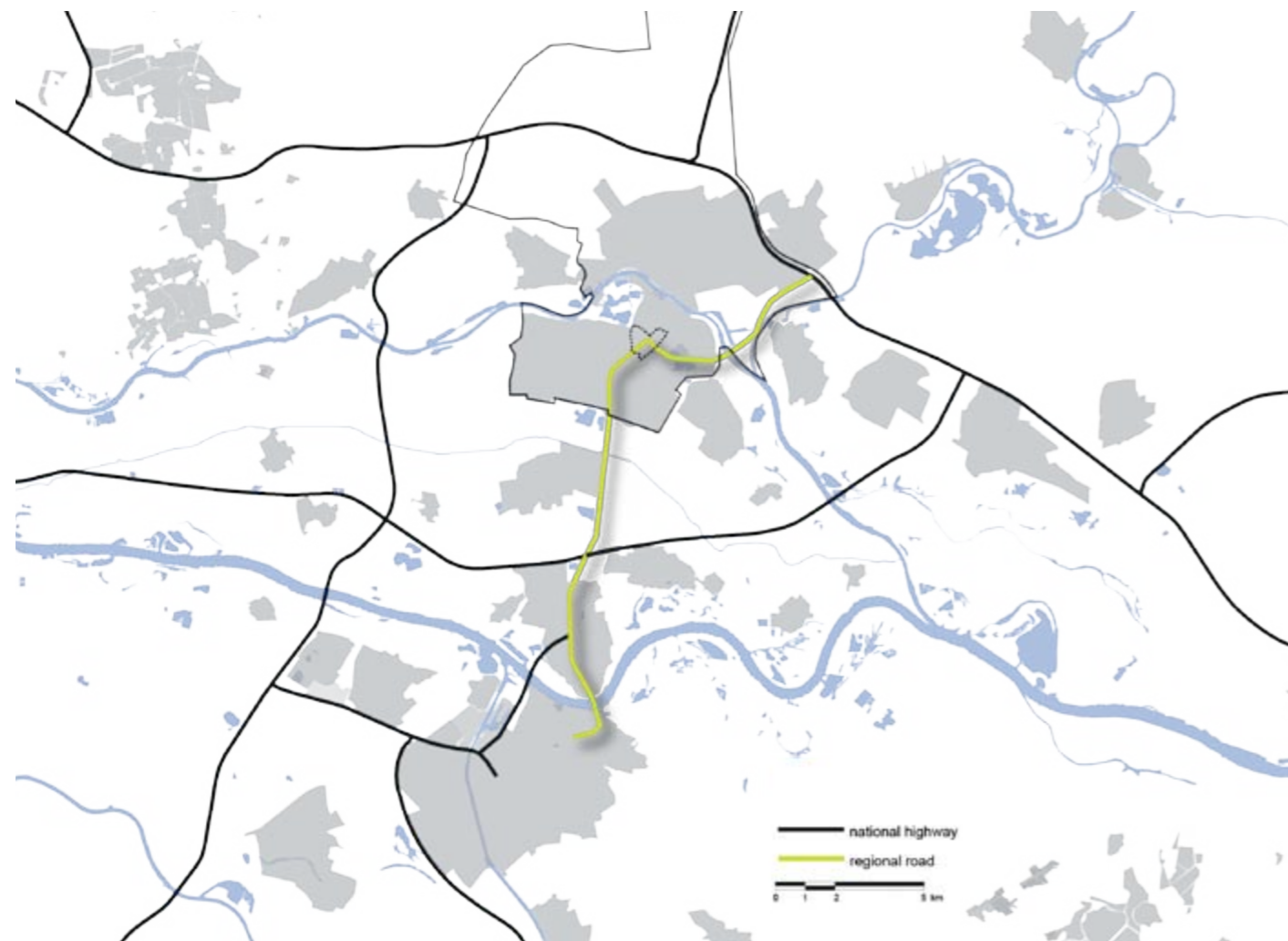


Figure 4.1 Traffic network in Arnhem-Nijmegen City Region in 2050

The HOV network is simplified into three axes in Arnhem-Nijmegen (Figure 4.2). Axes-A will go through Arnhem city from east to west, starting from Ede, Wageningen, to Westervoort, Duiven and Zevenaar. Axes-B will cross Nijmegen east to west, connecting Beuningen, Nijmegen central station, Radboud Universiteit Nijmegen, Groesbeek, and finally will arrive in Kleve in Germany. Using highway A325, Axes-C travels will start in Apeldoorn, Arnhem, Elst, Nijmegen-Lent, Nijmegen and will end in Malden. Two transit nodes of three axes will be close to Arnhem central station and Nijmegen central station. The HOV network will reach those towns, which are not close to railway stations at this moment, and will provide seamless transit for different transport modes.

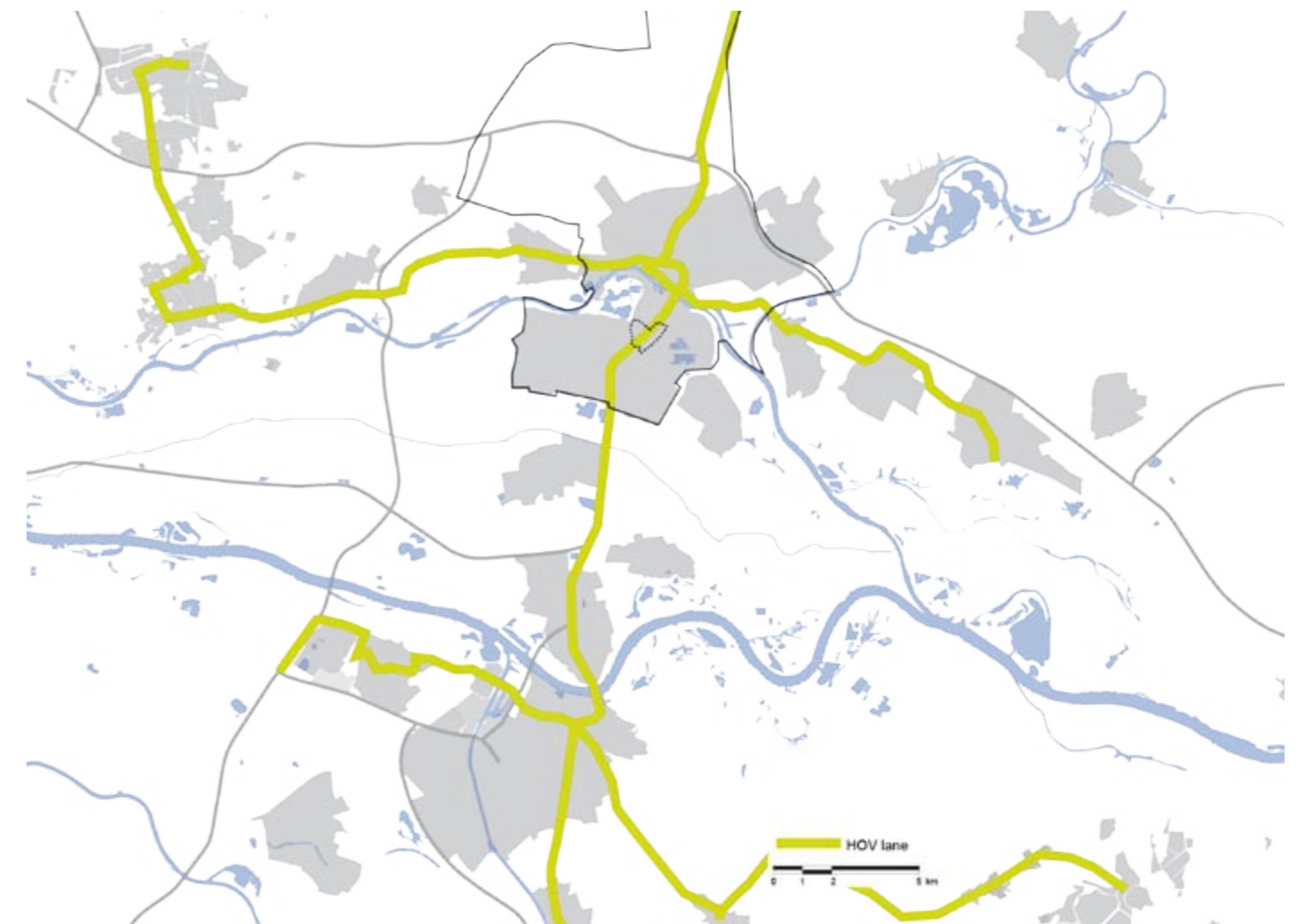


Figure 4.2 Transit Boulevard in Arnhem-Nijmegen City Region in 2050

A cycling route will be also included in the Transit Boulevard (Figure 4.3). It will follow the railway tracks, connecting business zones and residential areas. It will give people an alternate option for travel between home and office. Therefore, the traffic demands could be released during the peak hours more or less.

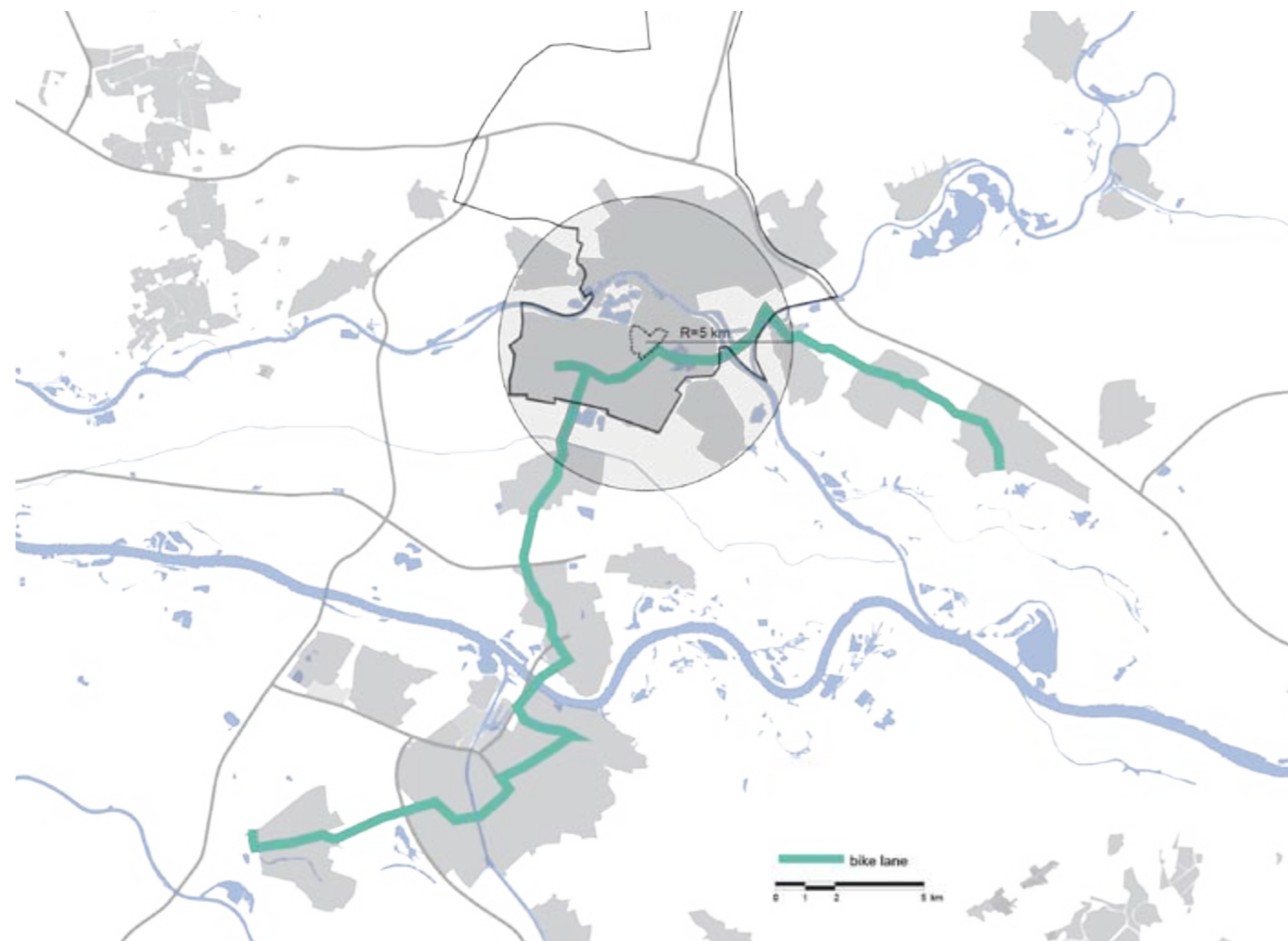


Figure 4.3 Bike route in Arnhem-Nijmegen City Region in 2050

The bike route, HOV network and the town centres form the Transit Boulevard. It will be the backbone of passenger transit between Arnhem and Nijmegen. More urban developments would be applied in the town centres and within the Transit Boulevard, it provides various transport modes (Figure 4.4).



Figure 4.4 Transit Boulevard in Arnhem-Nijmegen City Region in 2050

Meanwhile, the Throughways will locate on highways. The intersections of the highways will be the new location of car-oriented developments, such as light factories, warehouses (Figure 4.5).

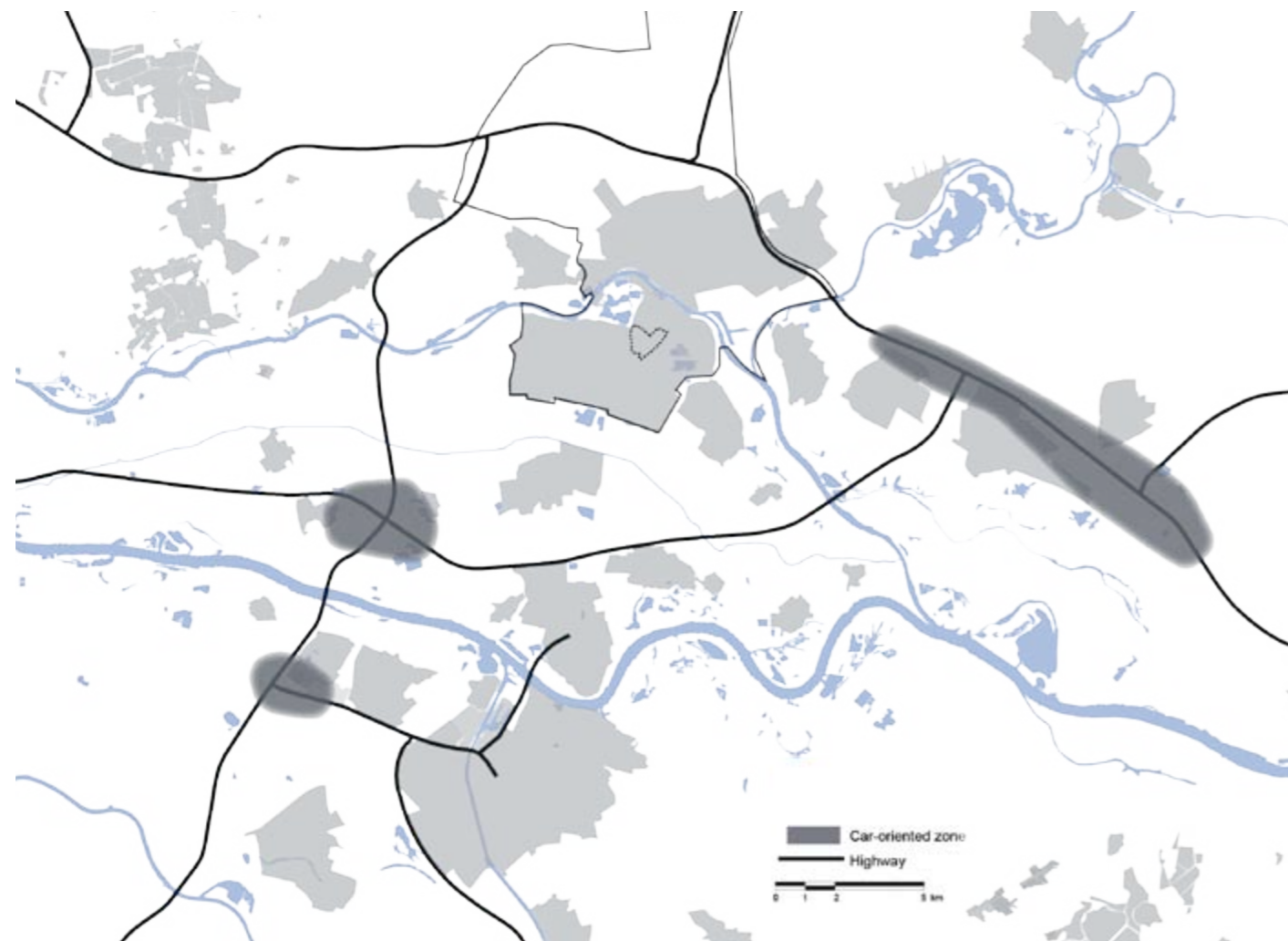


Figure 4.5 Throughways and car-oriented land use in Arnhem-Nijmegen City Region in 2050

Arnhem-Nijmegen City Region will development follow the S-shape. The green field of the in-between area will be preserved. At the intersection of Highway A15 and A325, this area could be the energy production area, for it has good connection with highways and has appropriate distances with Arnhem and Nijmegen (Figure 4.6).



Figure 4.6 Transit Boulevard in Arnhem-Nijmegen City Region in 2050

4.2 City

4.2.1 Strategy

Arnhem brands itself as trolleybus city, as the trolleybuses network in Arnhem is the only trolleybus network in the Netherlands and one of the largest in Western Europe. Since Arnhem has already equipped their public transport with electricity, the bikes and private cars could also be electrified in the future.

4.2.2 Suitable transport modes: Electric bus & E-bike

As it is mentioned before, the HOV network will be applied in Arnhem by 2050. Two axes will go through Arnhem centre and one will go through Arnhem south centre. The HOV network will be BRT, for its low investments and flexibility on capacity and routes. Because of the long travel distance, it is hard to build the wire for trolleybuses system; the HOV buses will be electric buses with batteries.

The extra power of electric bikes makes up for the shortcomings of the conventional bikes, and makes cycling more attractive to the residents. Arnhem south is flatter than the north. This would be another trigger for the widespread use of bikes in the south bank. Although the price of electric bikes is higher than the conventional bikes, OV-Fiest, the bike rental service, could make the electric bikes affordable.

Highway A325 will be downgraded and ended at the intersection of Nijmegenseweg and Burgemeester Mastersingel. The split will reduce the traffic intensity in Arnhem south centre zone (Figure 4.7).

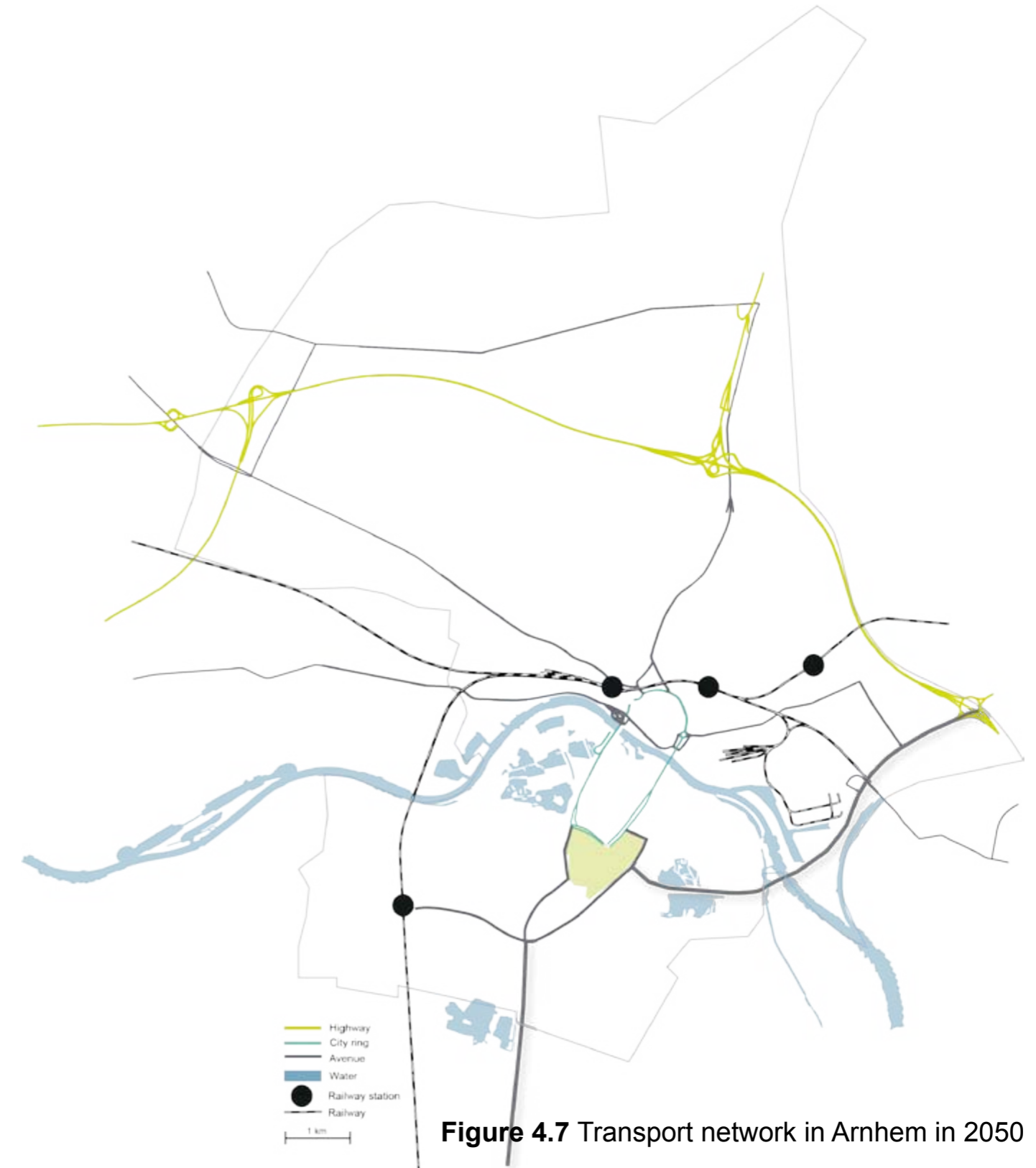


Figure 4.7 Transport network in Arnhem in 2050

In the future plan, the train, HOV and bike routes will be integrate and provide seamless transit. The transit hub will still be in Arnhem central station; Arnhem south centre will be better connected to the regional public transport than before (Figure 4.8).

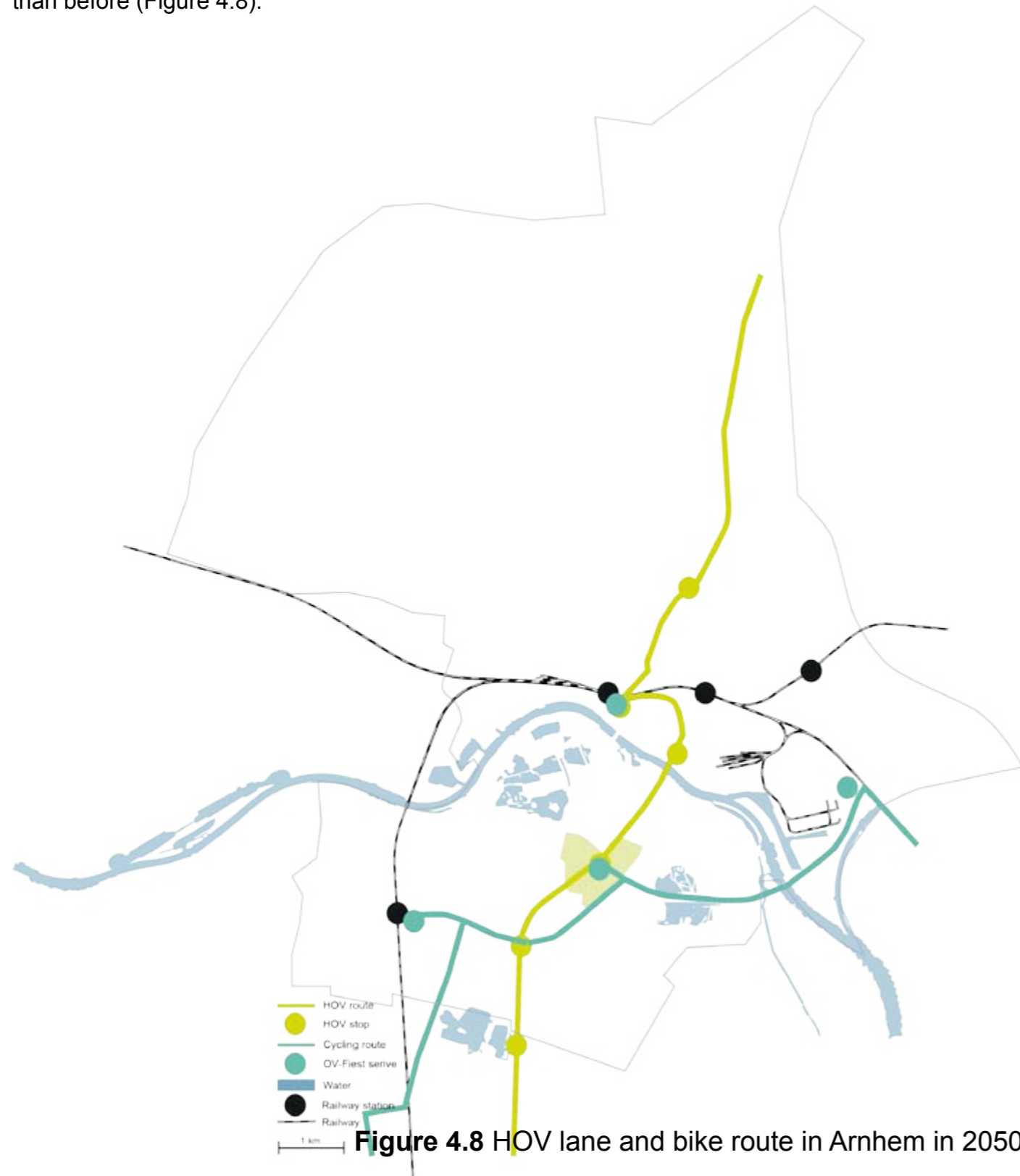


Figure 4.8 HOV lane and bike route in Arnhem in 2050

OV-Fiest bike rental service spots will locate next to the railway stations, the transit node in Arnhem south centre and in the business zone in the north bank (Figure 4.9). It could provide seamless transit from trains or the regional buses to bikes and also it will promote the bike use between offices and homes.

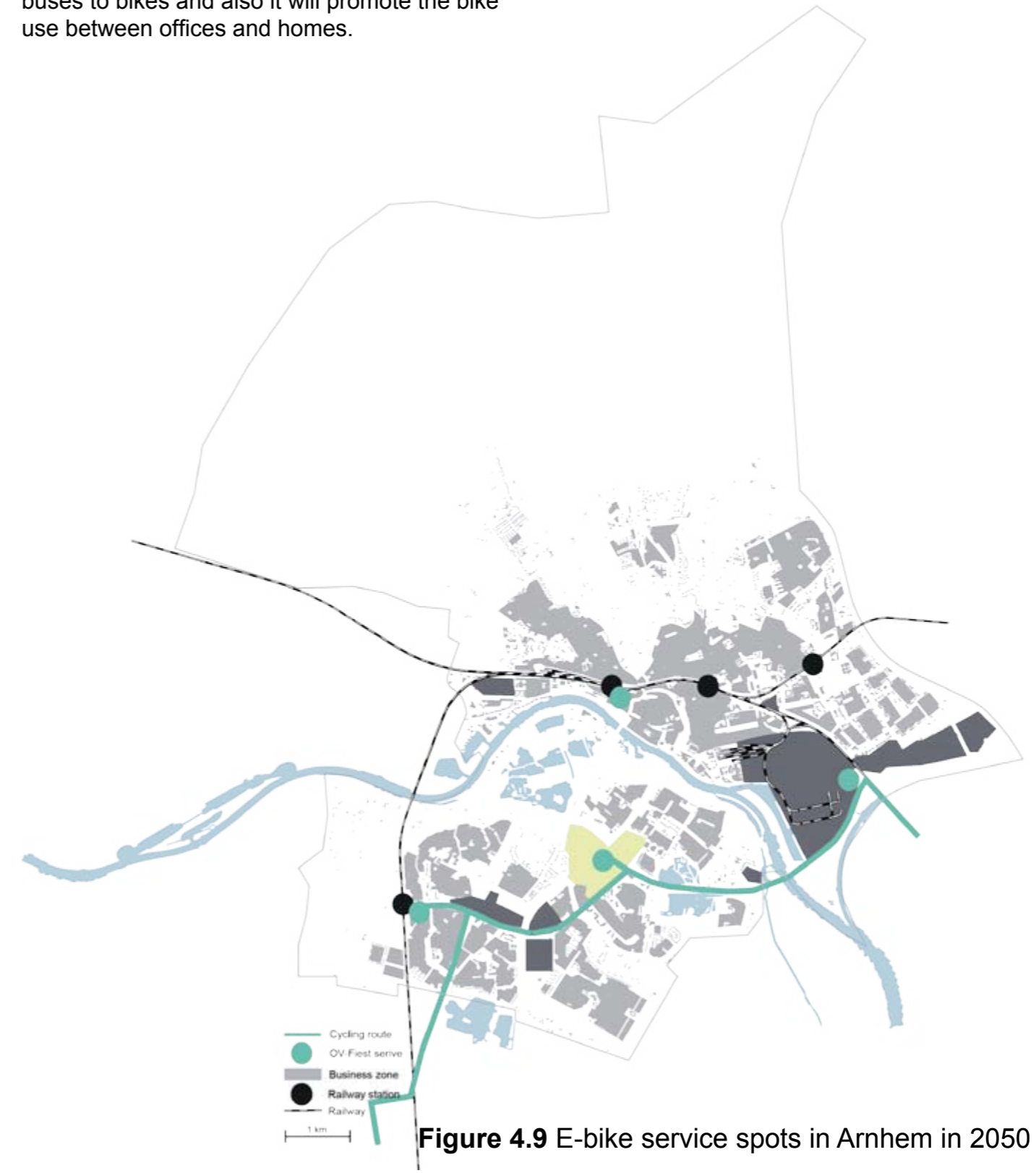


Figure 4.9 E-bike service spots in Arnhem in 2050

HOV will go through Arnhem both north and south centres. The distance between each HOV stops will be around 3km in the urban area (Figure 4.10). The regional buses will stop at town centres, main business zones, universities and other attractions.

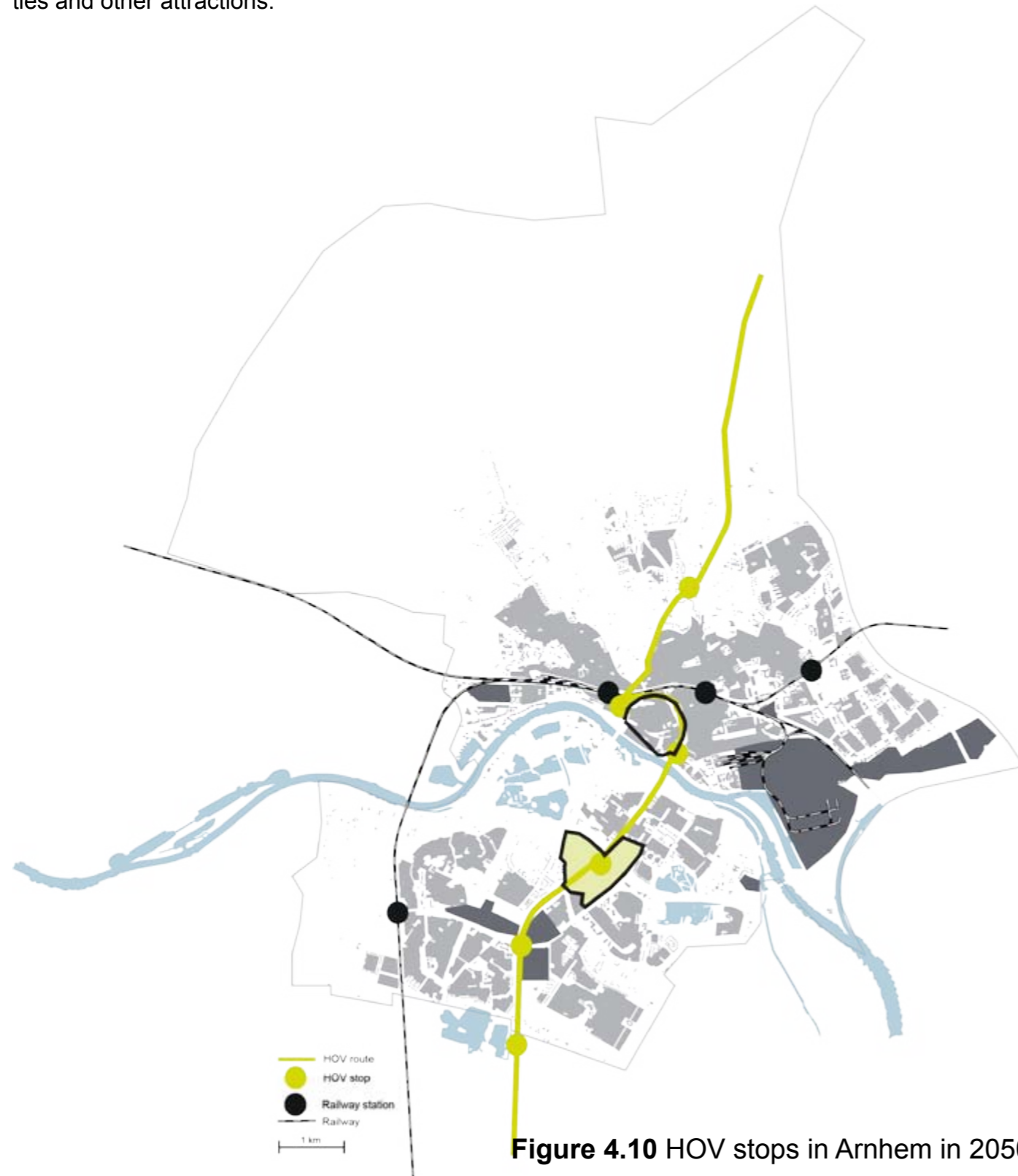


Figure 4.10 HOV stops in Arnhem in 2050

4.3 District

4.3.1 Strategy

The main idea for the project on district scale is to transform Arnhem south centre zone into an energy and space efficiency neighbourhoods. On one hand, the urban spaces give priority to walking, cycling and public transport, which consume less energy and spaces than private cars. On the other hand, the urban developments around the transit nodes are mixed-use neighbourhoods with high density. The public spaces around three public buildings would hold various activities for the south residents.

4.3.2 Suitable transport modes: E-bike, bike, walking

Arnhem south centre zone is about 1km by 1km. this is a fairish distance for walking and cycling. The urban design task is to make sure people could have a comfortable and safety walking and cycling experience.

4.3.3 Roads and parking facilities

In the plan, highways will be cut off at the edge of the core centre zone, so that drivers will have to go a detour or choose other roads. The private cars will not be allowed entering the core centre zone, except the emergency use. Regional buses and local buses could drive through the core centre zone and have several stops. The distances between regional bus stop and local bus stops will be around 100 metres, it will very easy for passengers to transit. The buses routes will use the existing road infrastructure as much as possible. Part of the

former tunnel will be transformed into bus lanes (Figure 4.11).

The individual transport is also considered in the project. All the private cars will be asked to park in the automated parking garages at the edge of the core centre zone. The charging facilities combining the parking garages around buildings could be helpful with persuading people give up their diesel cars and use PHEVs as the replacements.

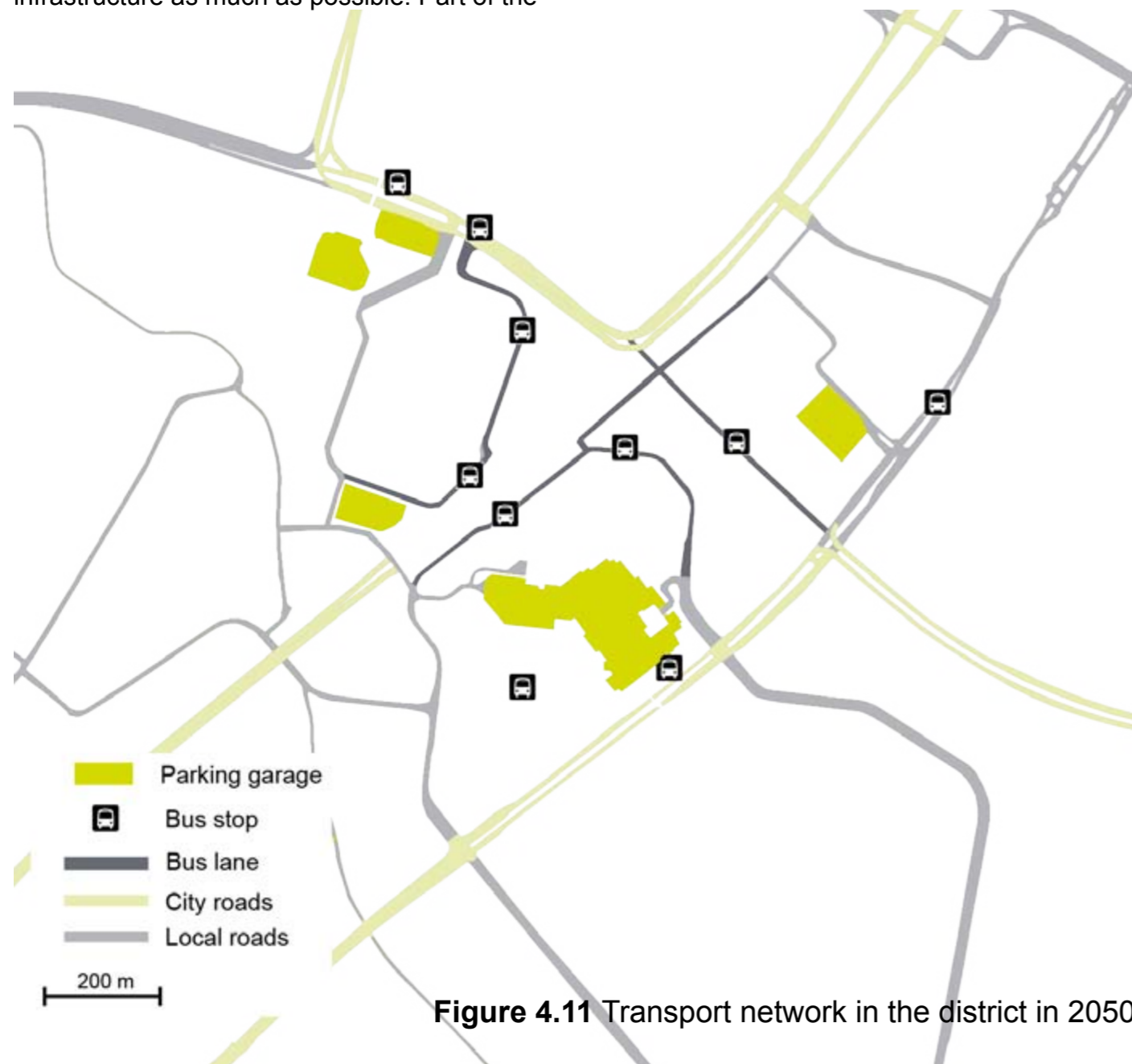


Figure 4.11 Transport network in the district in 2050

4.3.4 Comparisons

Based on the function, landscape and urban context, four urban space models (Figure 4.12, 4.13, 4.14, 4.15) are picked to compare with Arnhem south centre. All these four models present good examples for pedestrian-oriented environment in commercial or cultural urban spaces.

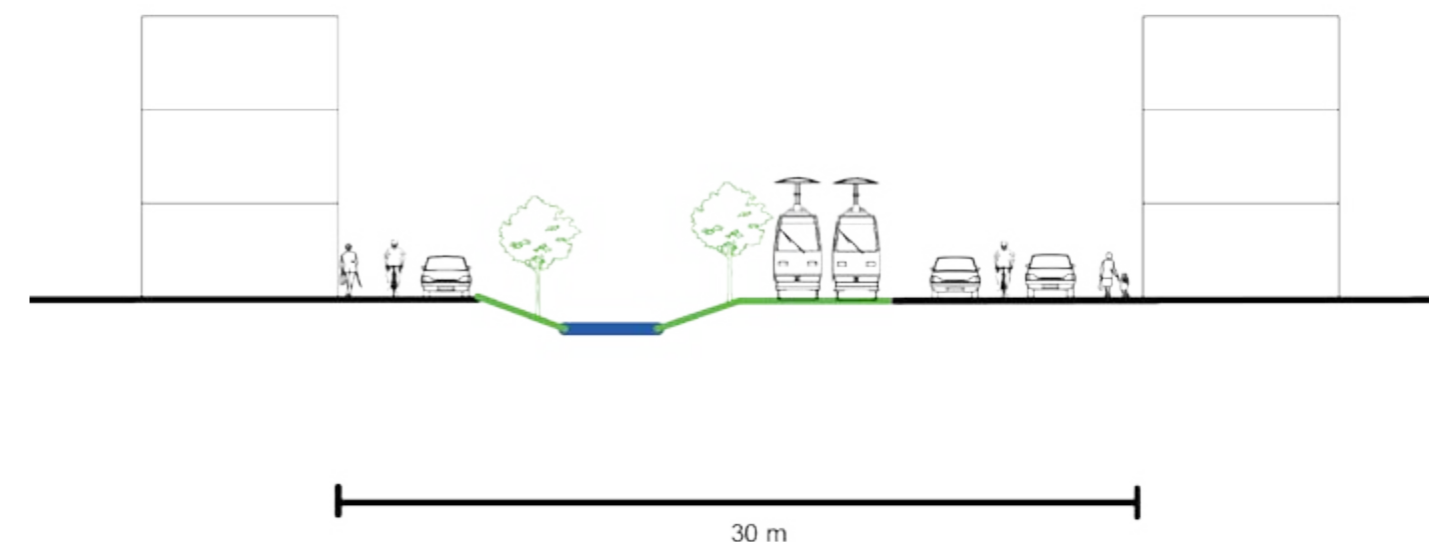


Figure 4.12 Urban space model of Rotterdam museum park

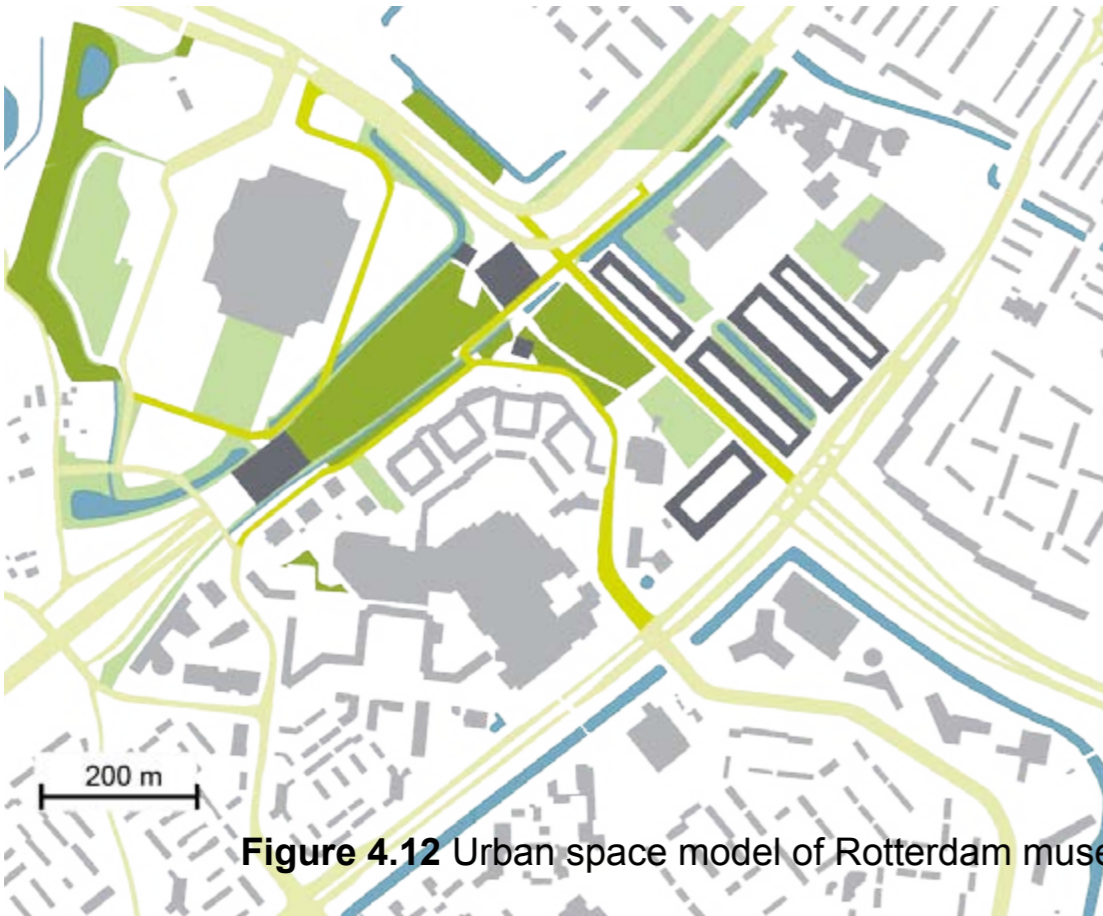


Figure 4.12 Urban space model of Rotterdam museum park

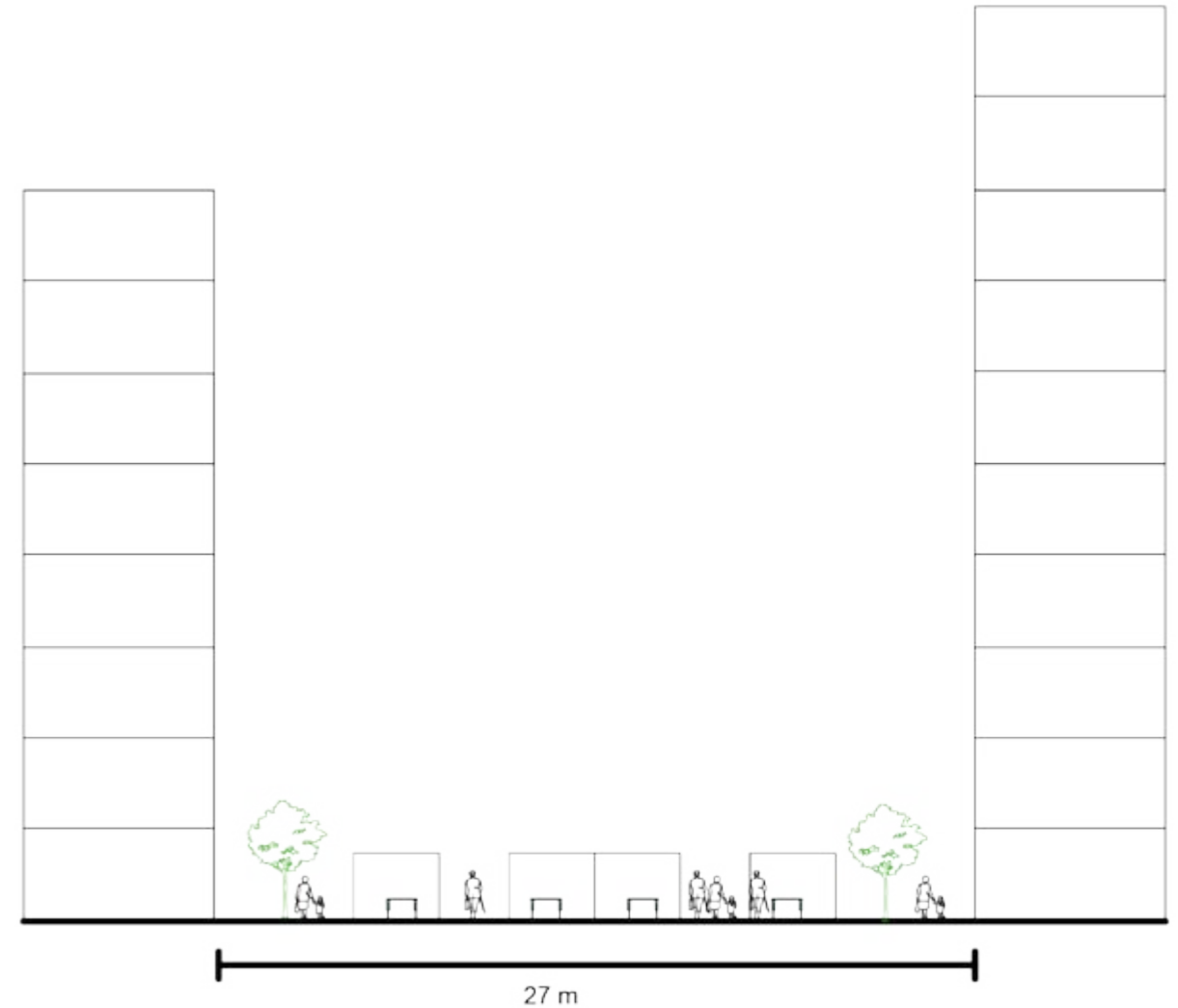


Figure 4.13 Urban space model of Rotterdam blaak

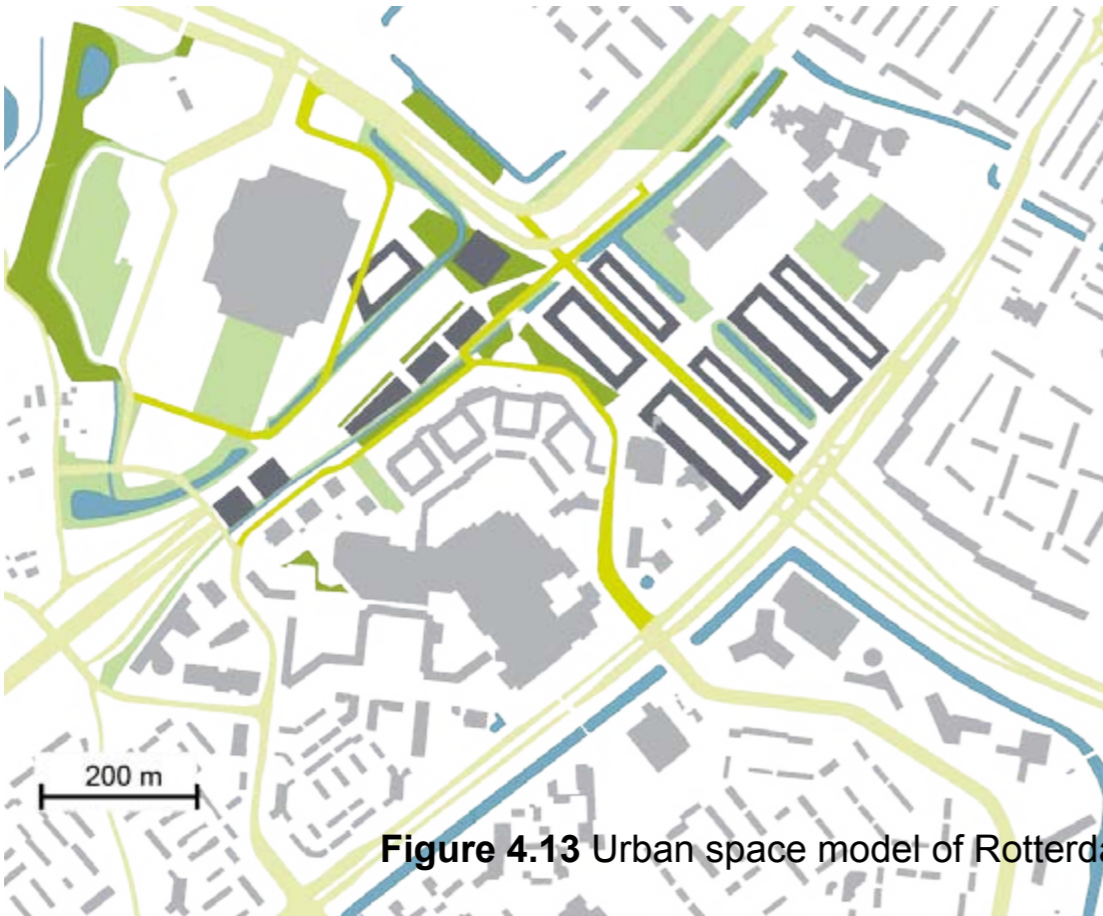


Figure 4.13 Urban space model of Rotterdam blaak

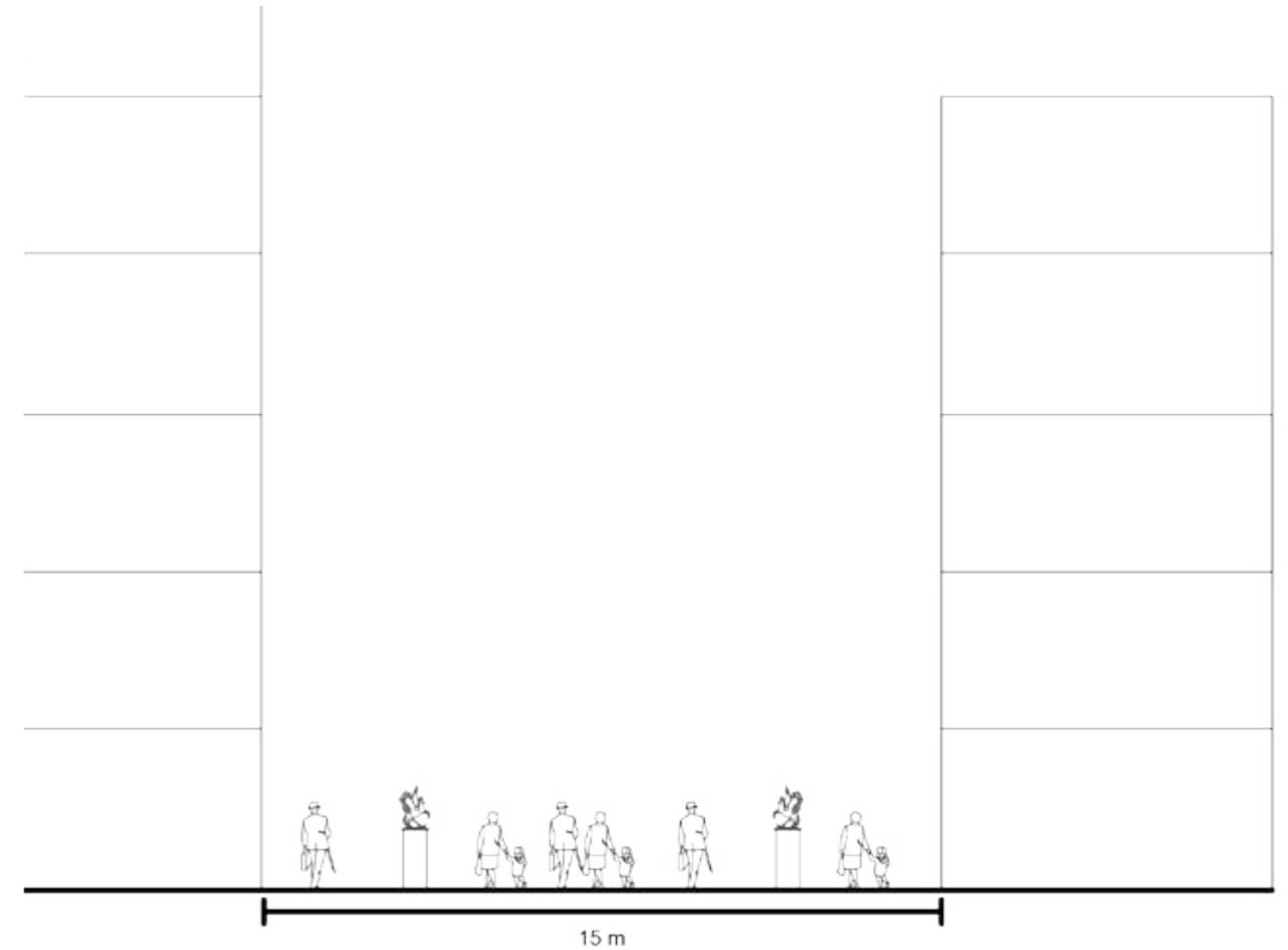
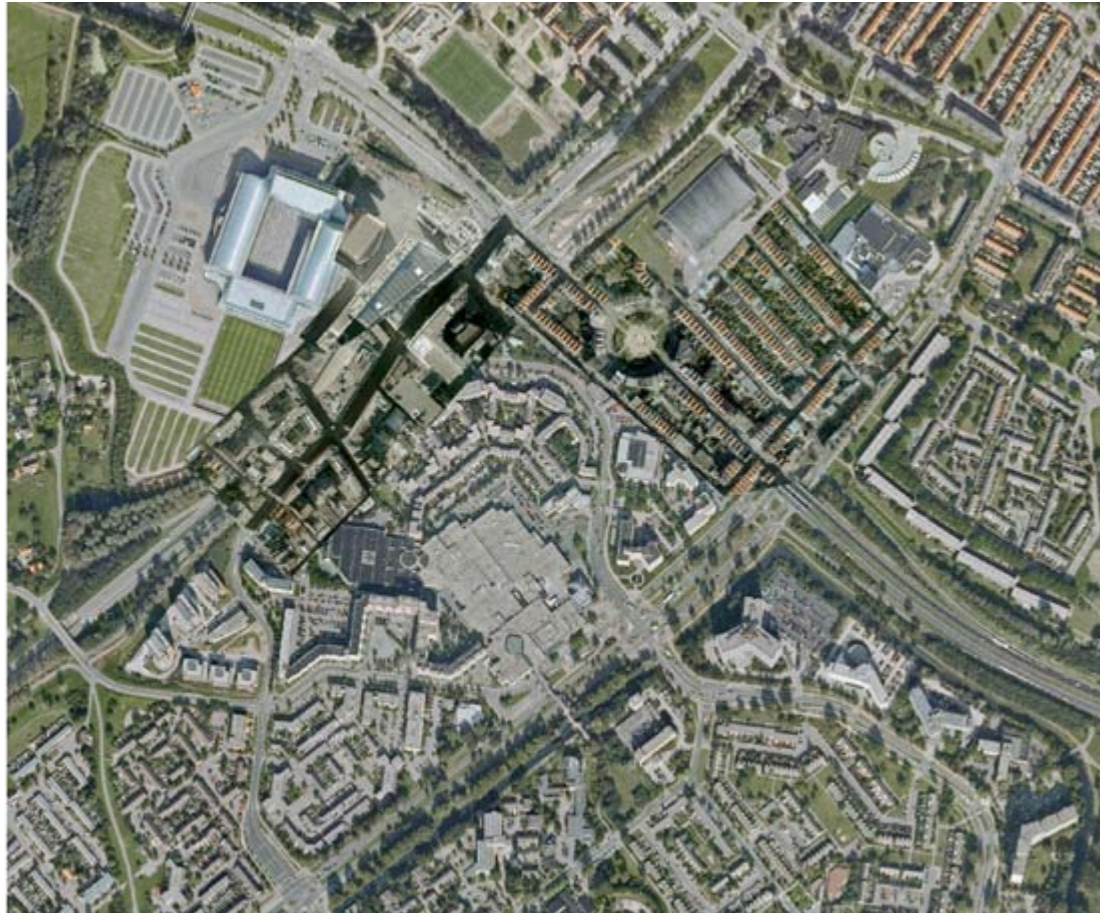


Figure 4.14 Urban space model of Den Haag



In conclude, the parking lots on the east of the stadium could be used as a weekly market square. The green field next to the intersection should be connected to the green belt to the north. All the new buildings need to fit into the existing neighbourhoods. Three to five floors are the ideal range for the new buildings.

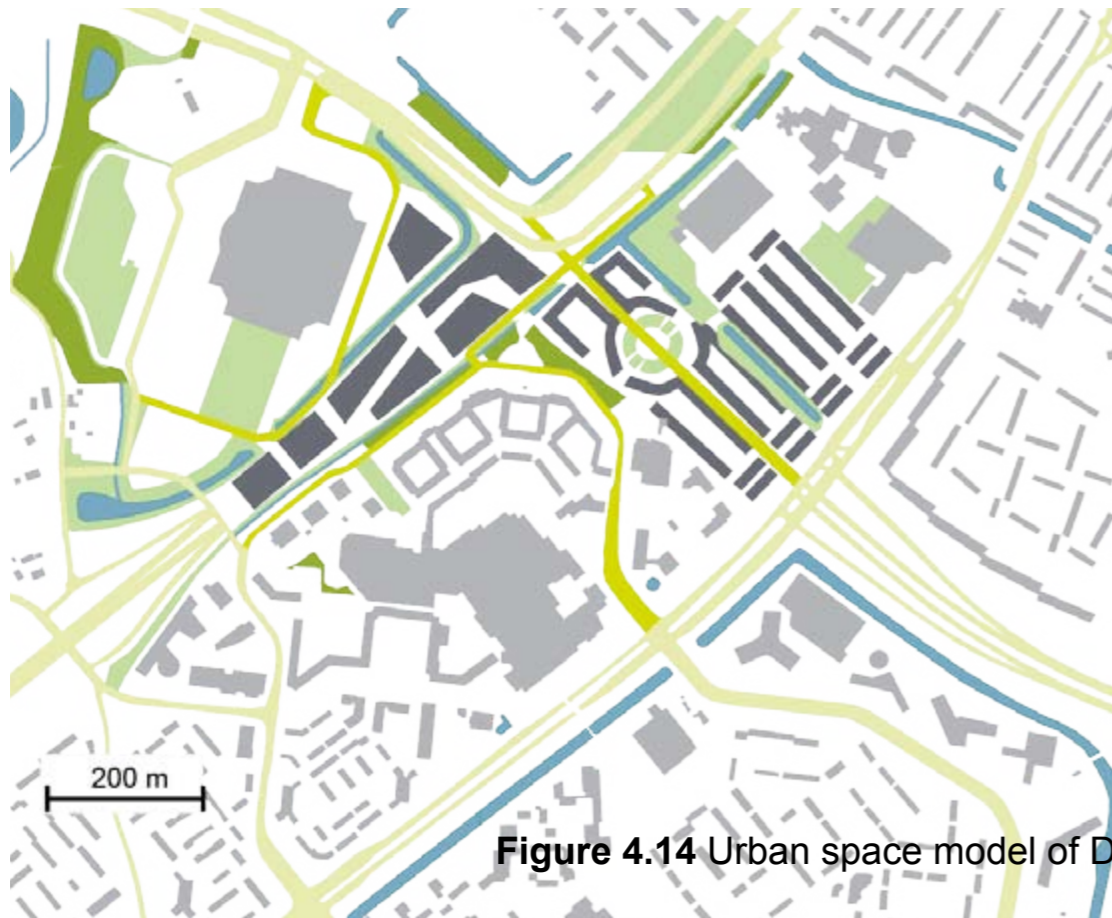


Figure 4.14 Urban space model of Den Haag

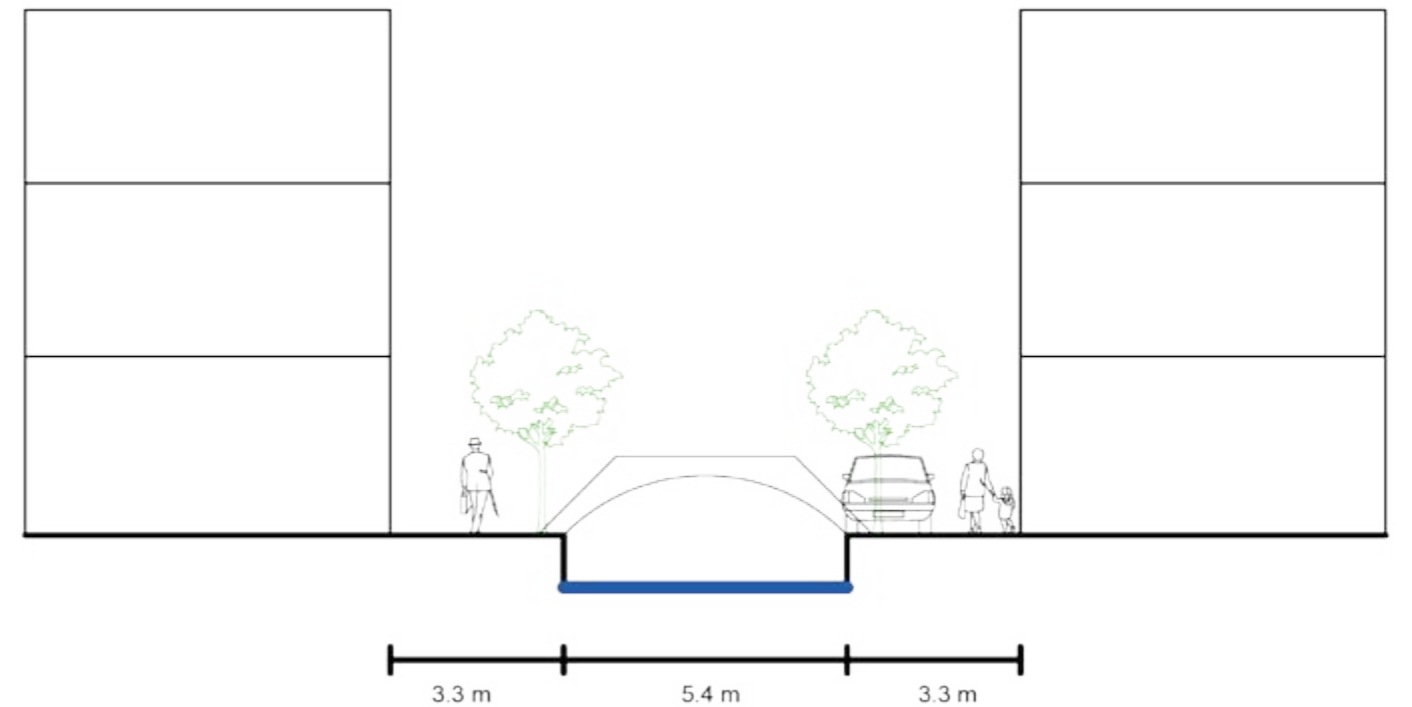


Figure 4.15 Urban space model of Delft

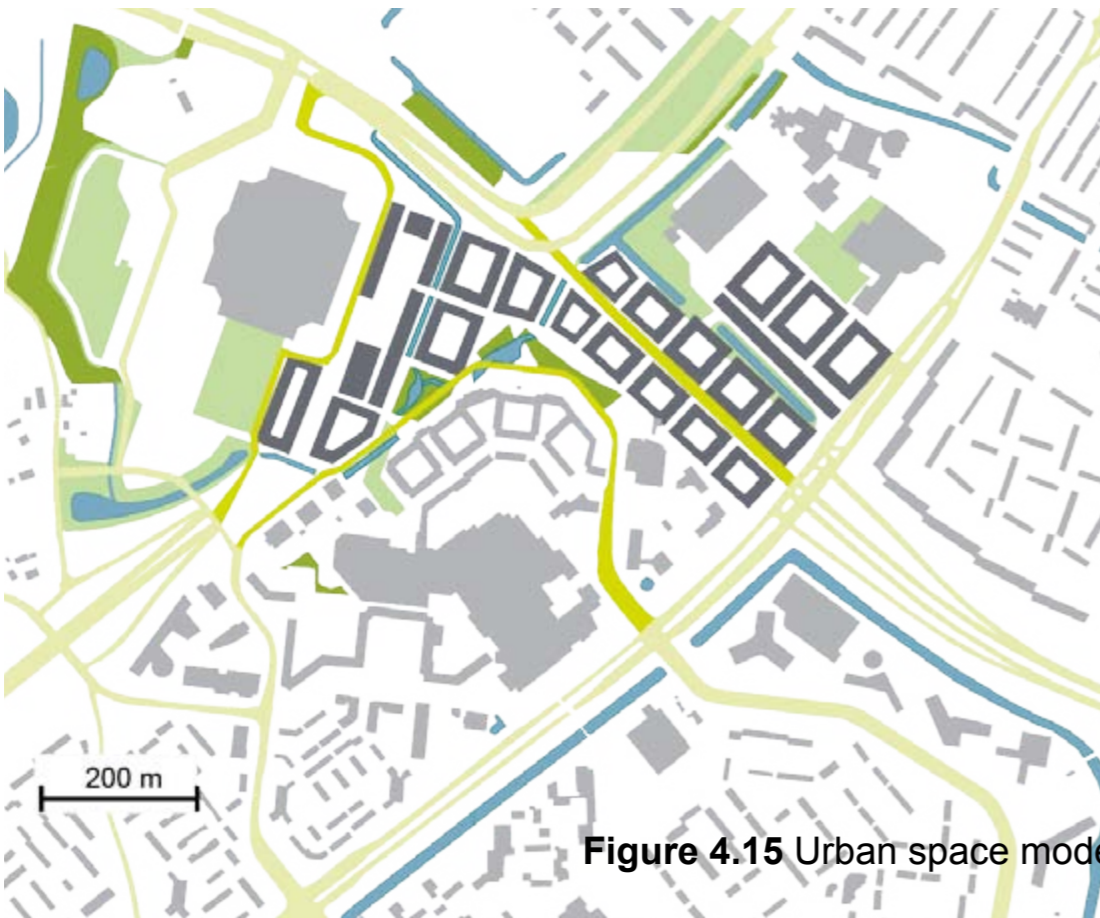
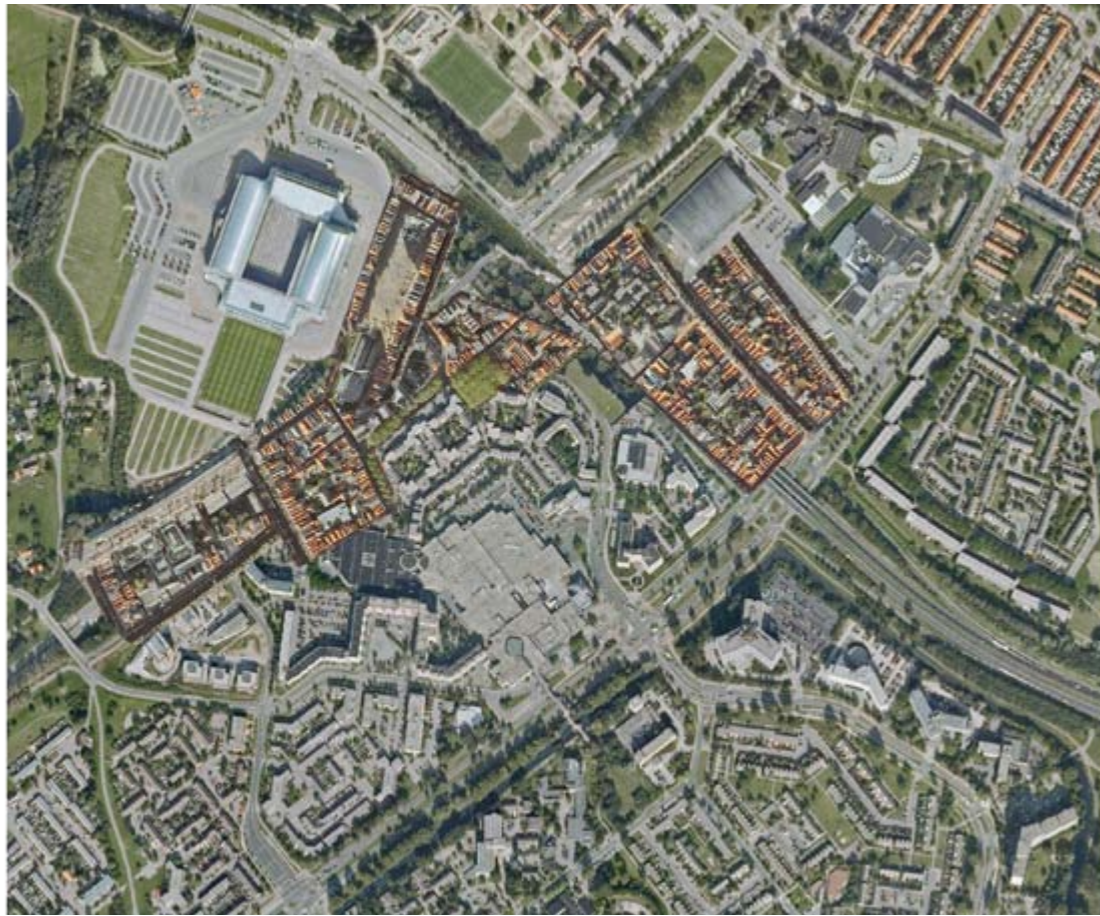


Figure 4.15 Urban space model of Delft

4.3.5 Structure

First, the areas of the former Highway A325 between the stadium and the shopping mall, it will become the new core centre of Arnhem south. In here, it will be a transit node and new mixed-use low-rise buildings. Second, in the area of former highway N325 between Rijnhal and the shopping mall, it will be filled up with residential buildings. Public spaces will be settled next to the canals. Third, the former parking lots next to the three buildings partly will be transformed into automated parking garages, partly will be

new green fields, most of them will be squares. The volume of new building blocks will be like as the existing building blocks (Figure 4.16).

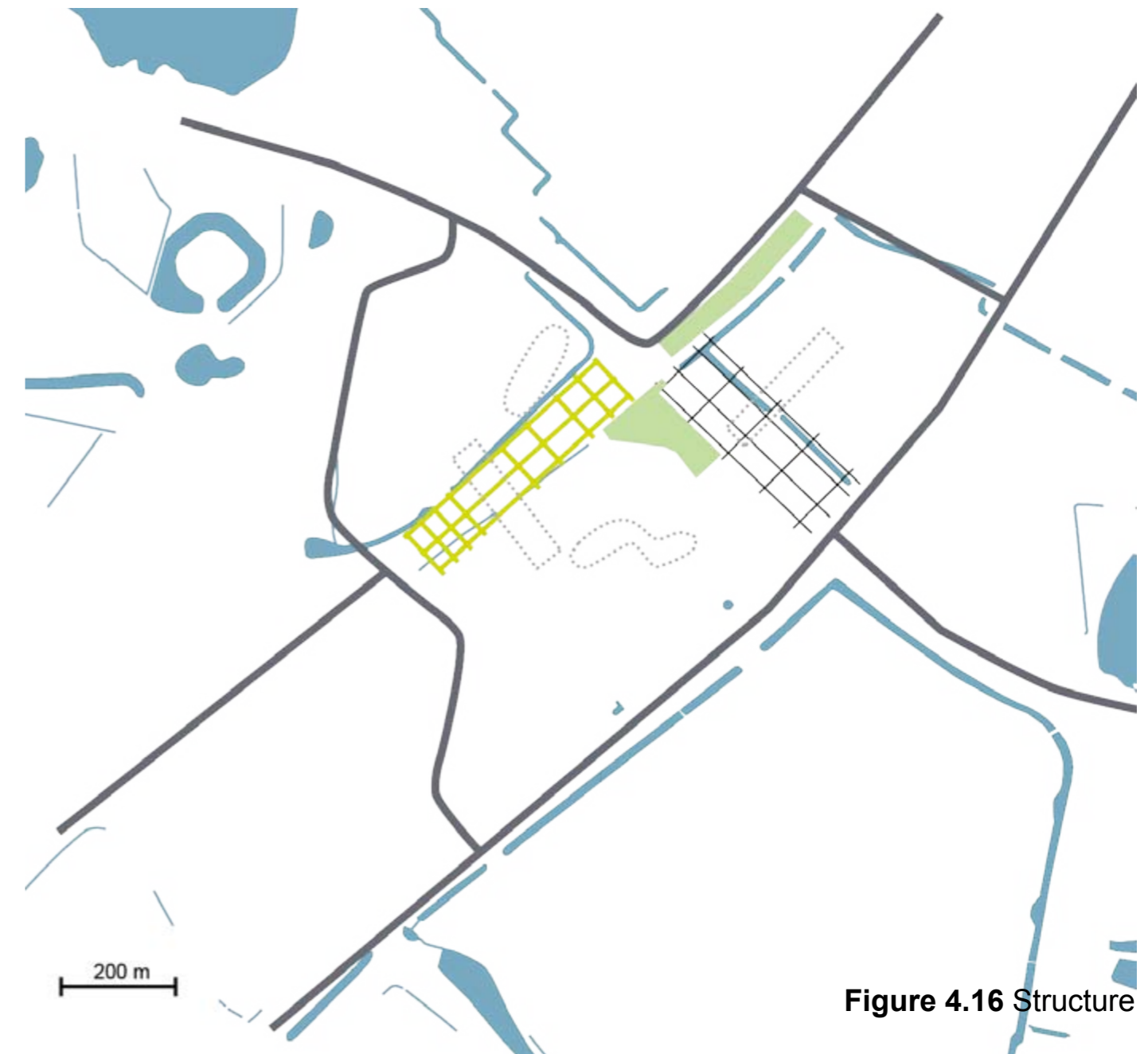
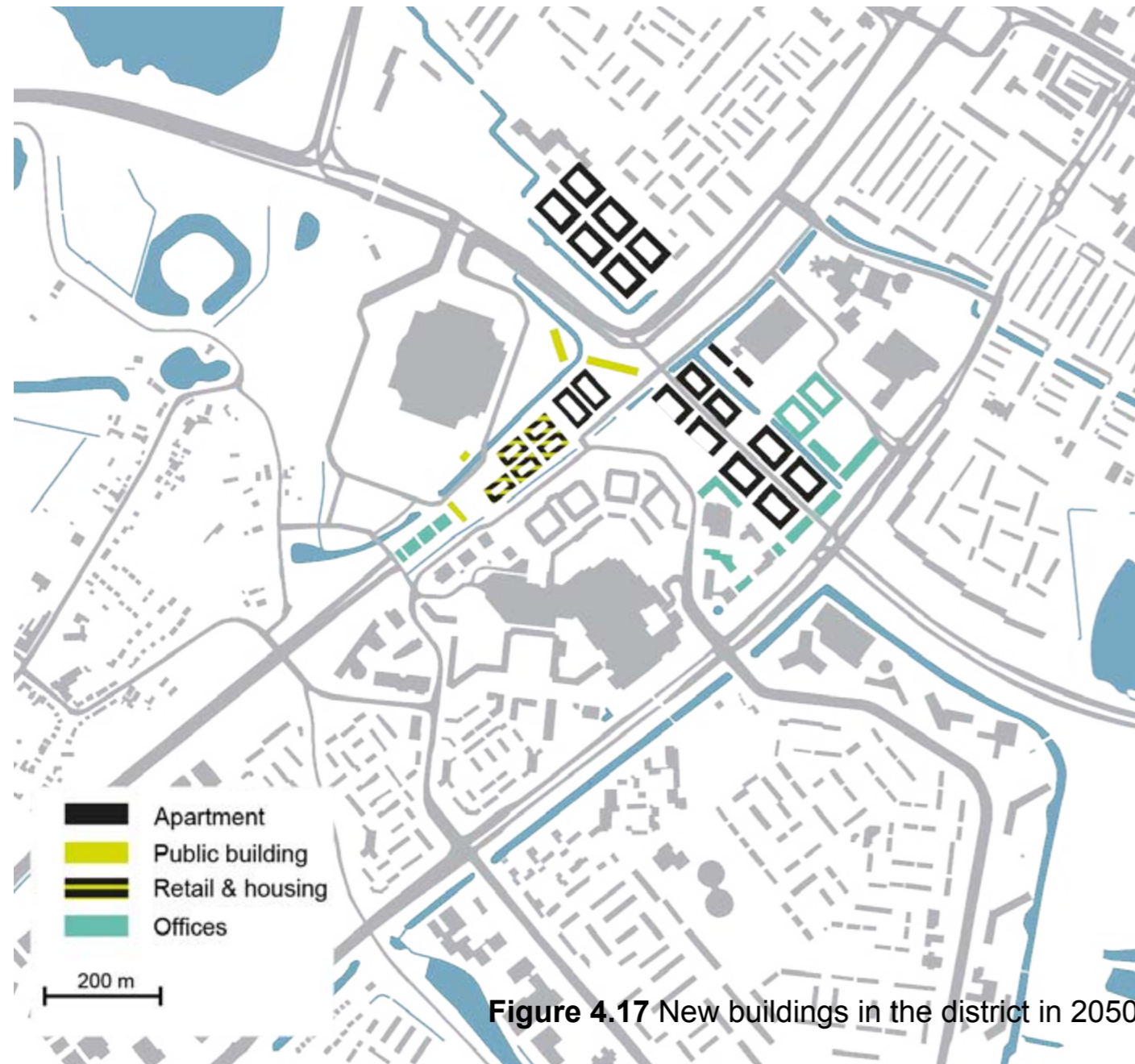


Figure 4.16 Structure

4.3.5 New buildings

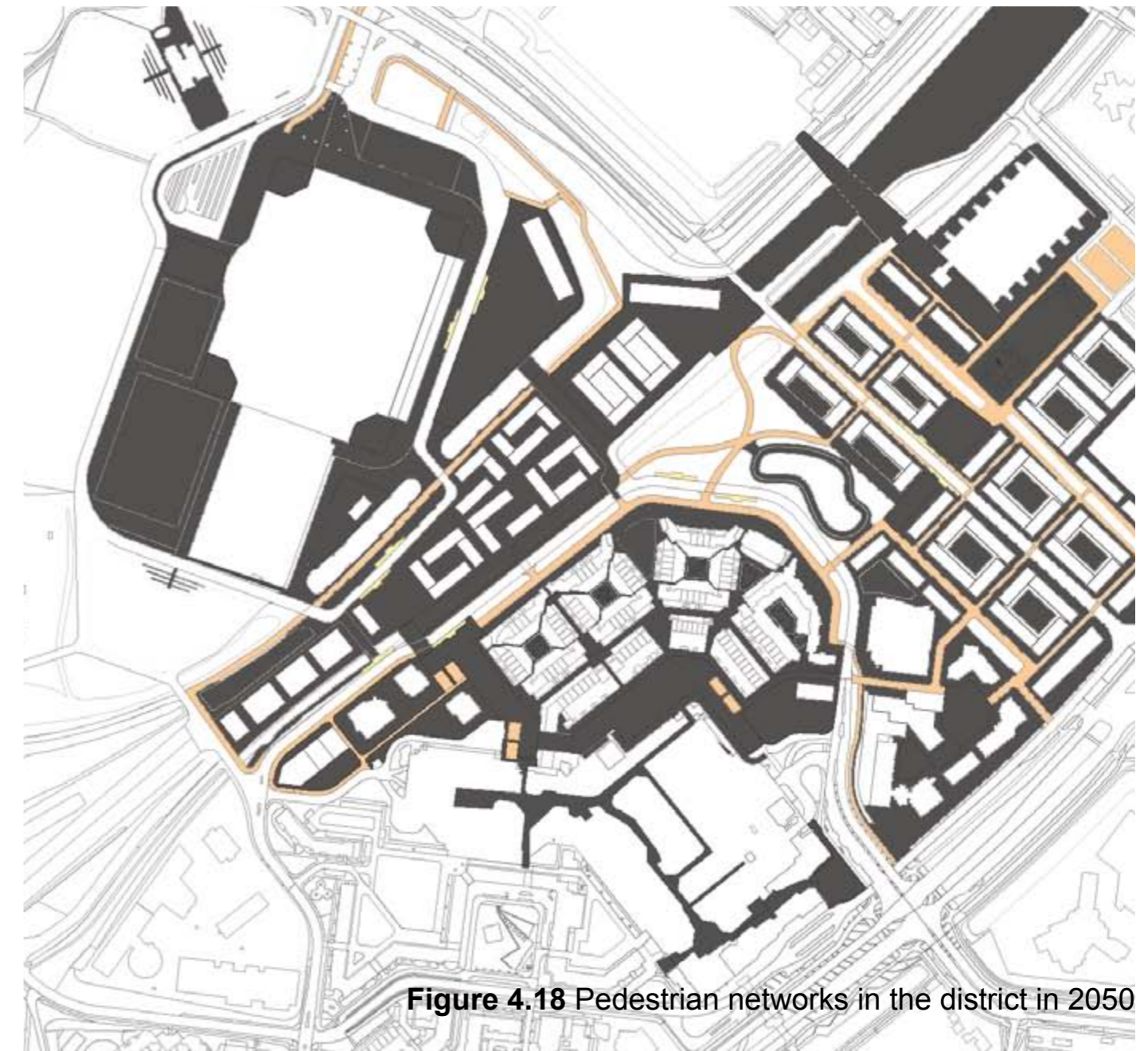
The first thing to do for improving the urban spaces in Arnhem south centre is to add new buildings in the vacancy spaces on and next to the highways and parking lots (Figure 4.17). In Zone A325, to the northeast, the two buildings will be cinema and theatre, providing culture life to Arnhem south. In the middle, the buildings will be 4-5 floors, the ground floor could be used as retails, restaurants or studios, booming the local business. To the southwest, the area next to the parking garage will be new busi-

ness zone. In Zone N325, new buildings on the northeast and southwest will be offices and the rest of them will be 3-4 floor apartments.



4.3.6 Urban spaces

The main goal of the project is improve the urban spaces on district level. If the buildings are the bones, forming the basic structure of urban pattern; the squares and the green fields are the fresh, holding various activities, and the pedestrian network is the vein, filling up the gap between buildings and public spaces and allowing people moving around (Figure 4.18).



Most of the green fields in the existing district are in highway buffer zone. Those green fields do not provide activities to the residents, so as the canals. In this plan, buildings and squares are added on the banks of the canals and parts of the green fields are transformed to parks (Figure 4.19). Most of the parking lots are new squares and parks in the future. The new buildings will be built on the former highways as much as possible, in order to minimize site disturbance.



Figure 4.19 Squares and green fields in the district in 2050

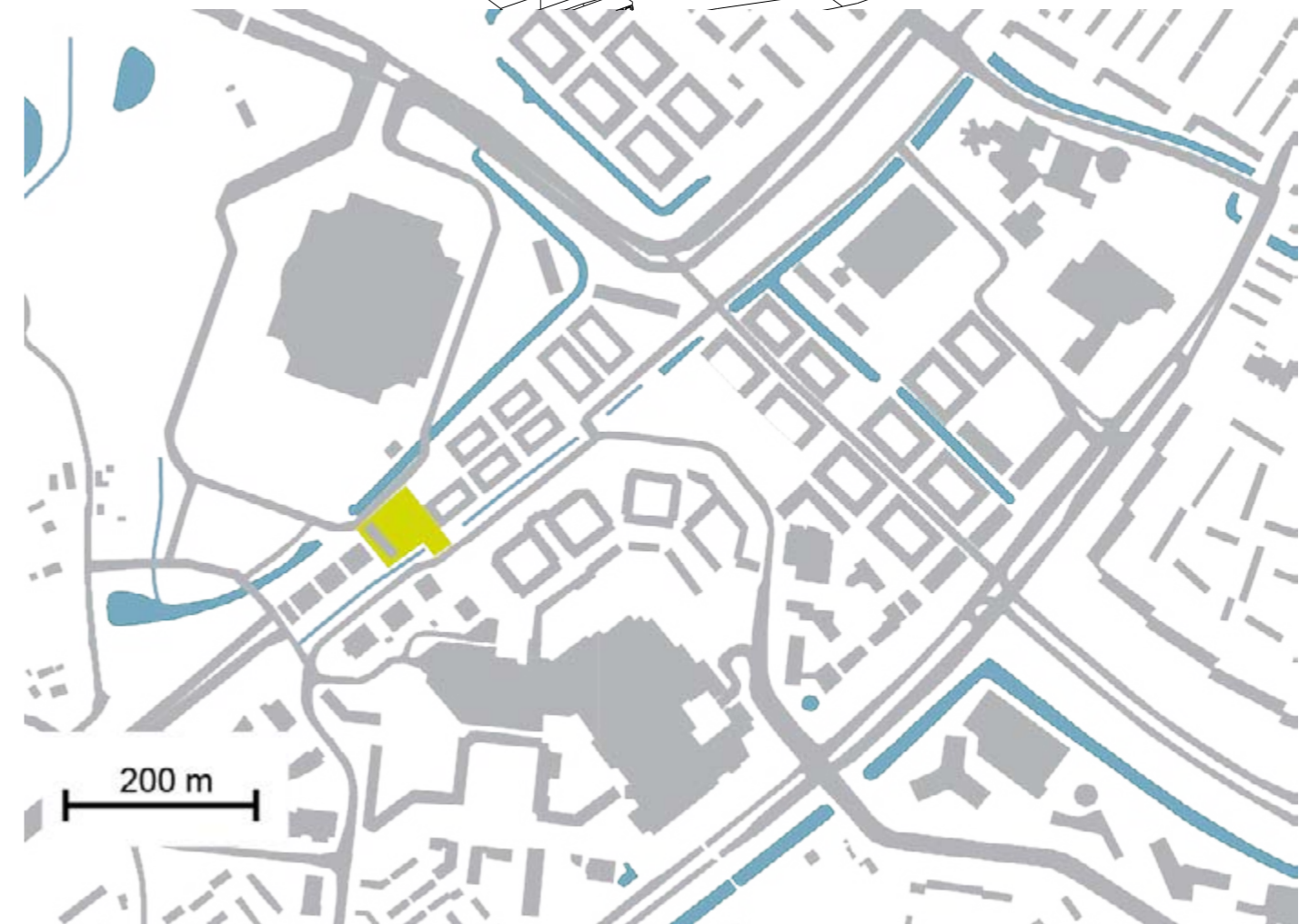
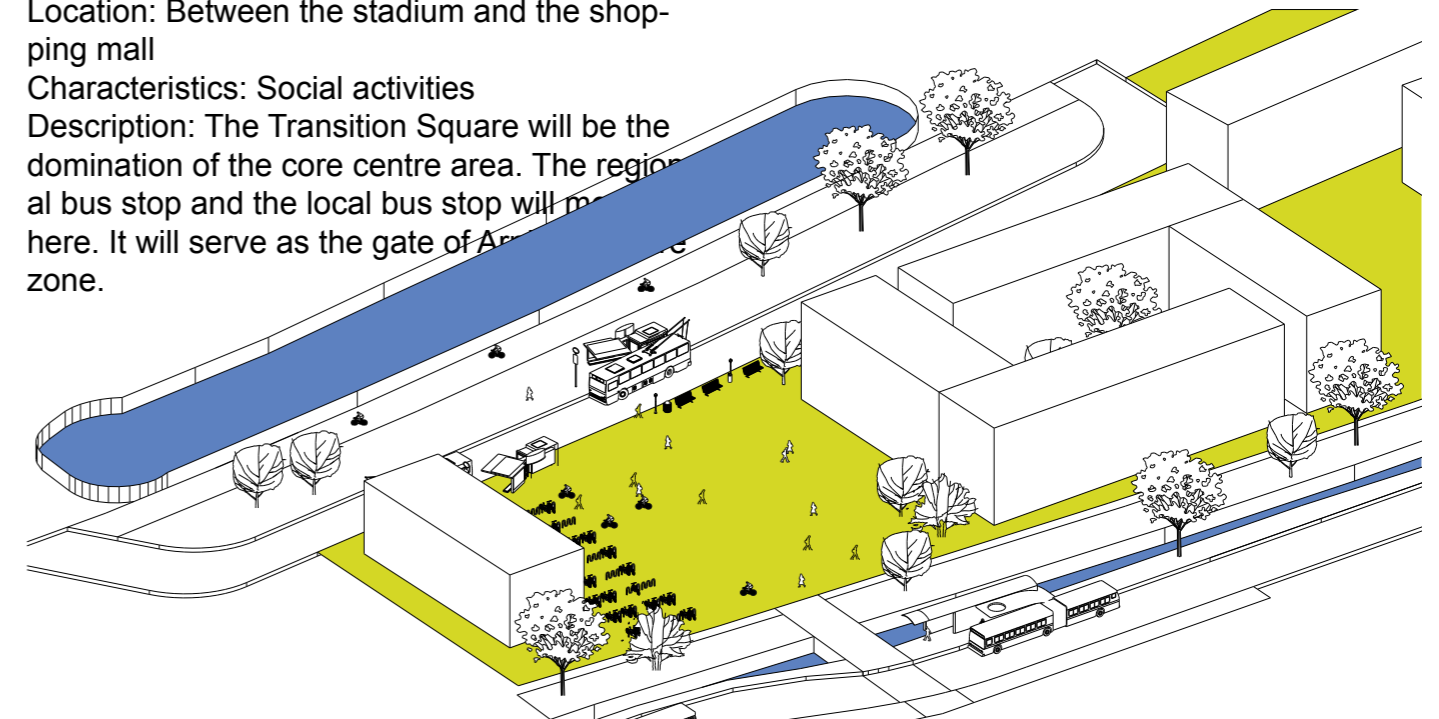
Squares

Type 1: Transition Square

Location: Between the stadium and the shopping mall

Characteristics: Social activities

Description: The Transition Square will be the domination of the core centre area. The regional bus stop and the local bus stop will be located here. It will serve as the gate of the core centre zone.

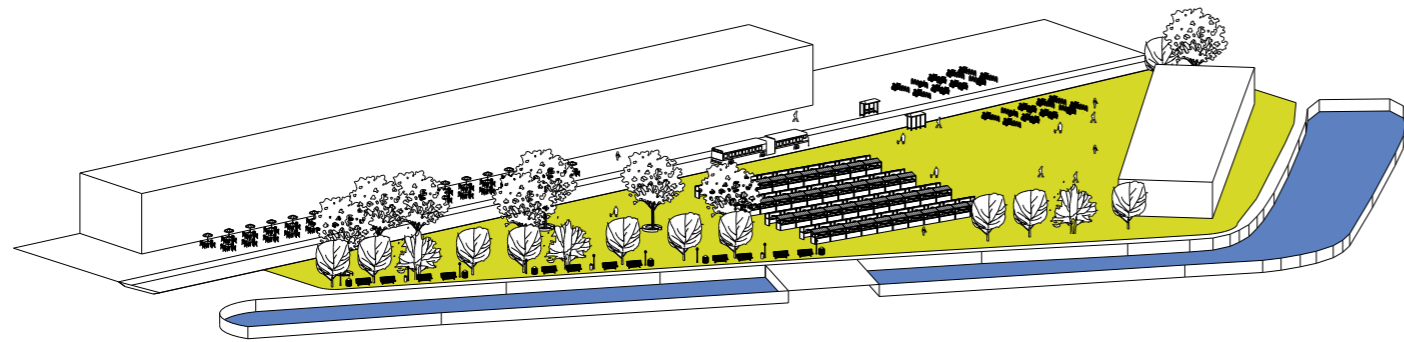


Type 2: Weekly market square

Location: Next to GelreDome stadium

Characteristics: Social activities

Description: This place use to be the parking lots. To the north of the triangular square will be a cinema, and to the west, there will be a new annex on the stadium, with retails and gyms. This square will be the biggest square in Arnhem south centre and it will hold big open-air events.

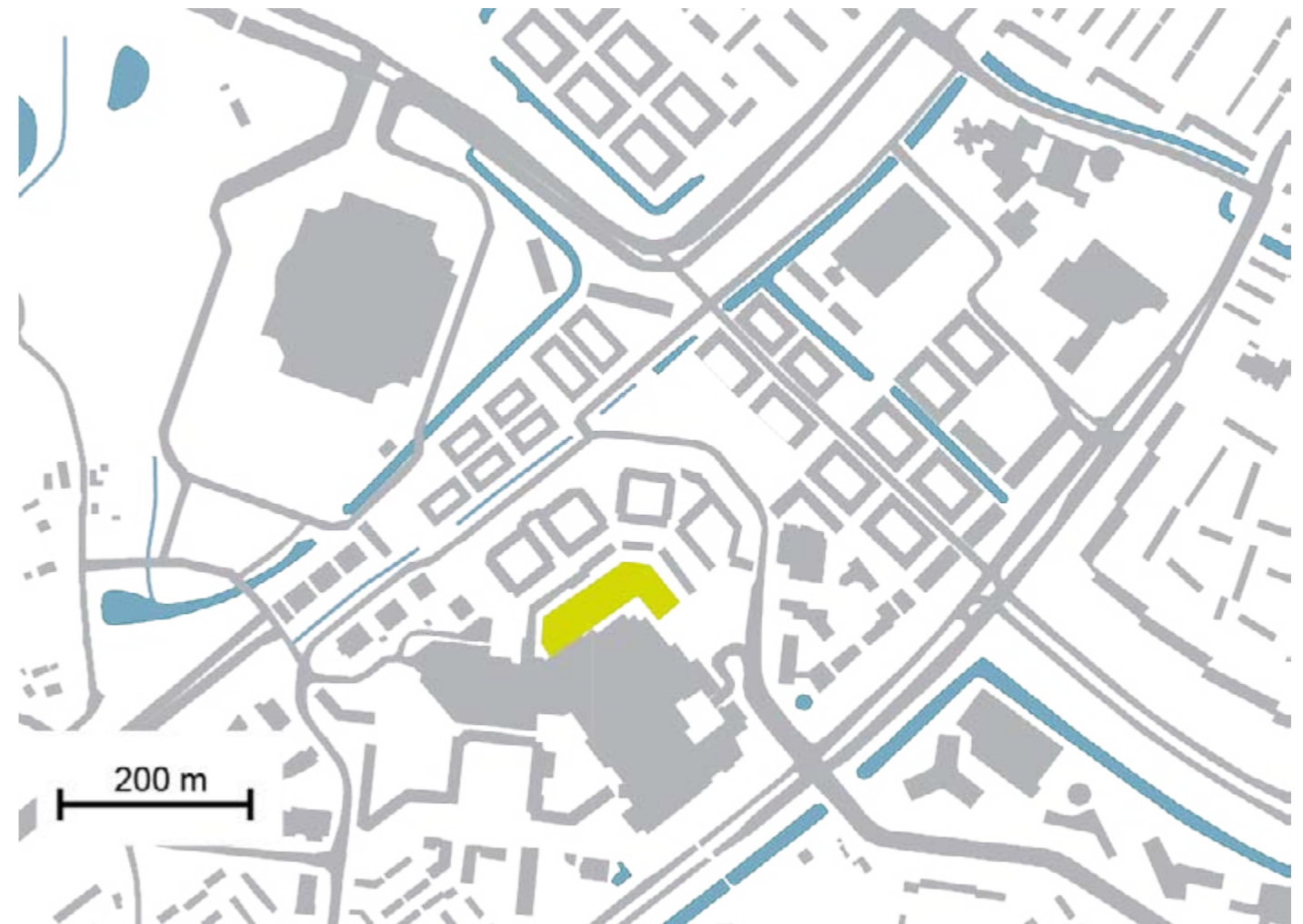
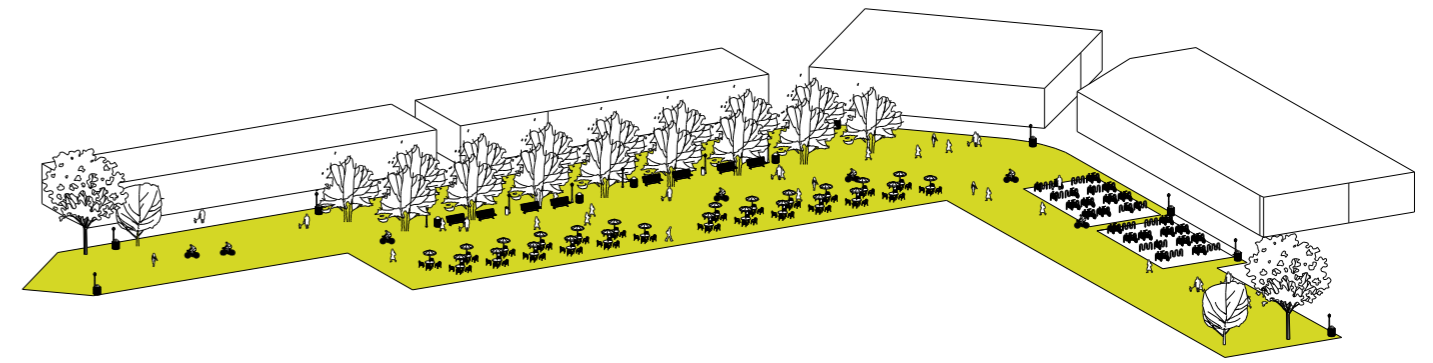


Type 3: Bar and cafe square

Location: To the west of the shopping mall

Characteristics: Social activities

Description: Bar and cafe square will be combined with the ground floor of the shopping mall, which will be transformed from parking lots into bars and restaurants. In this square, there will be many chairs and tables. It will be a good place for friends having a couple drinks after work.

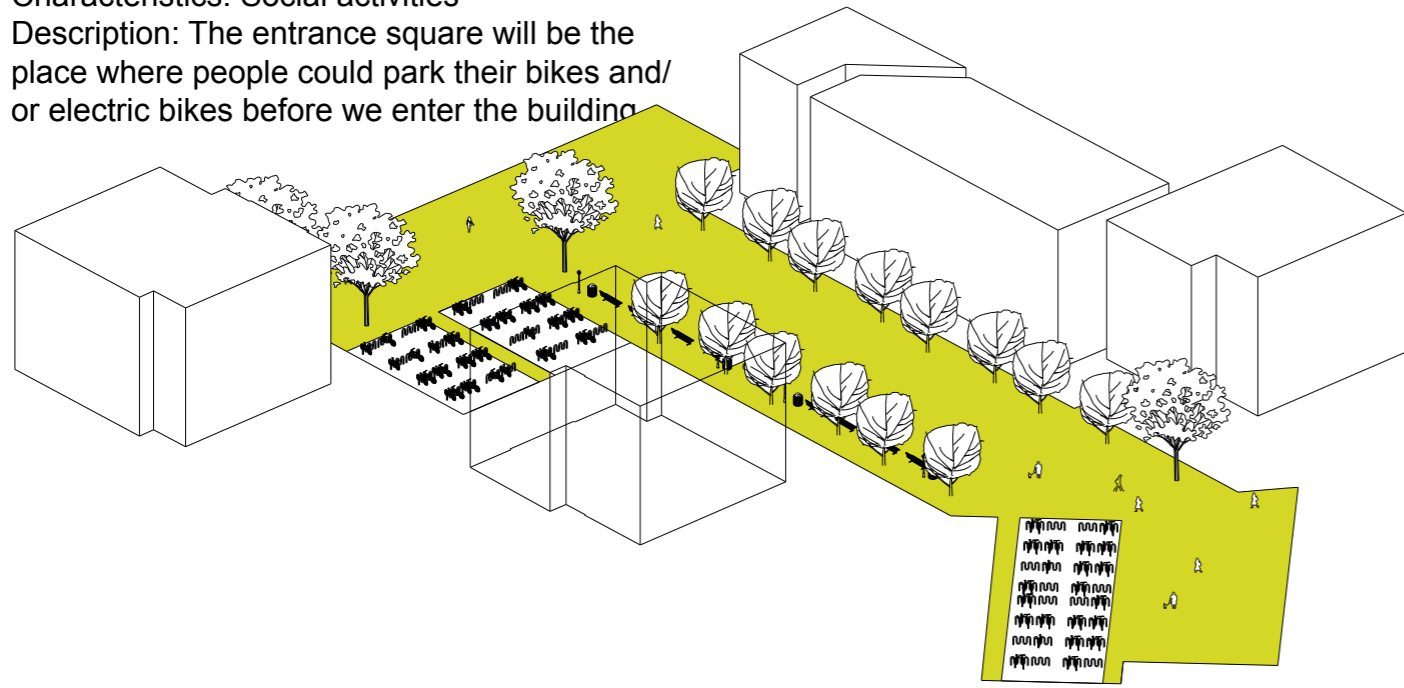


Type 4: Entrance square

Location: In the front of shopping mall, the stadium and the theatre

Characteristics: Social activities

Description: The entrance square will be the place where people could park their bikes and/or electric bikes before we enter the building

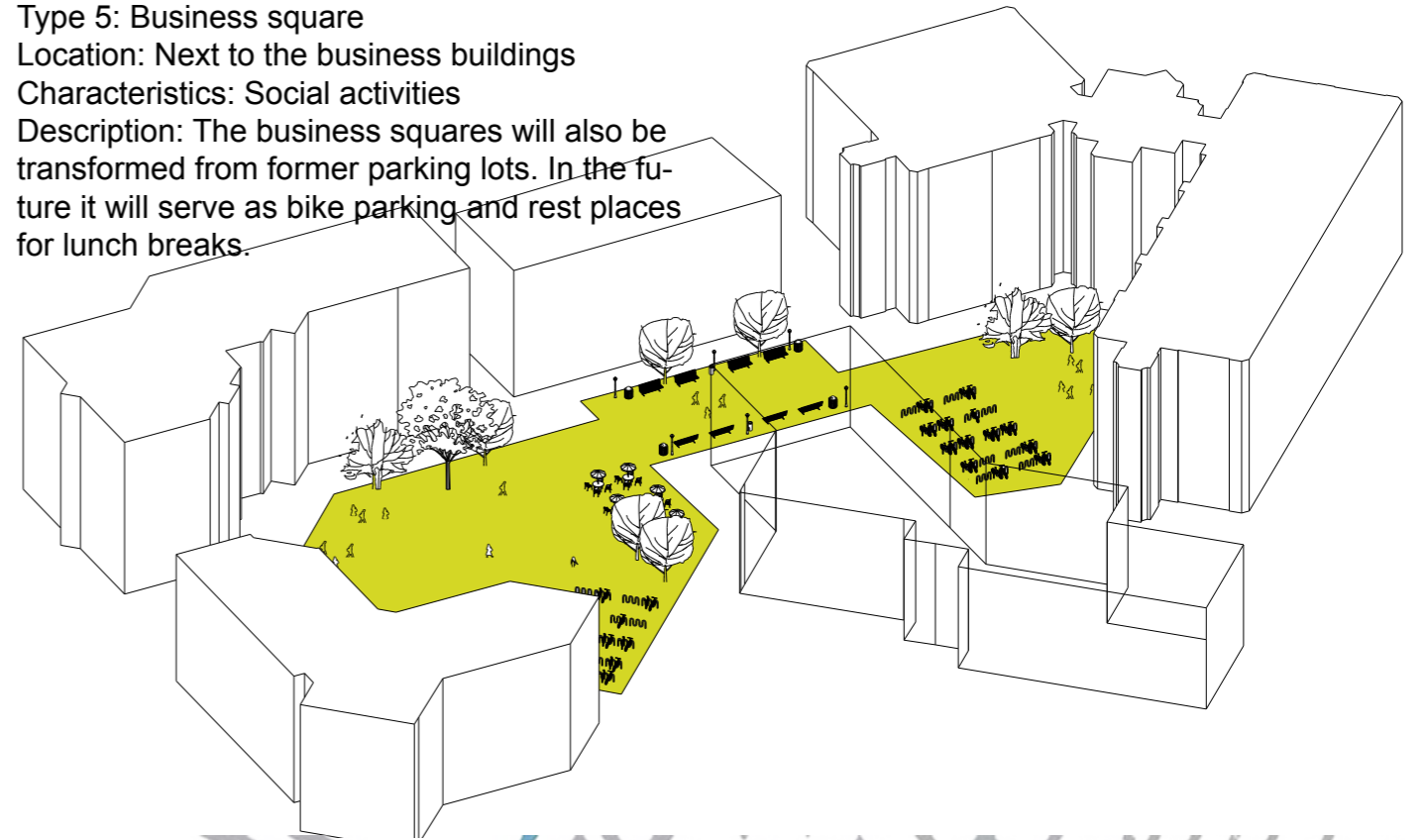


Type 5: Business square

Location: Next to the business buildings

Characteristics: Social activities

Description: The business squares will also be transformed from former parking lots. In the future it will serve as bike parking and rest places for lunch breaks.



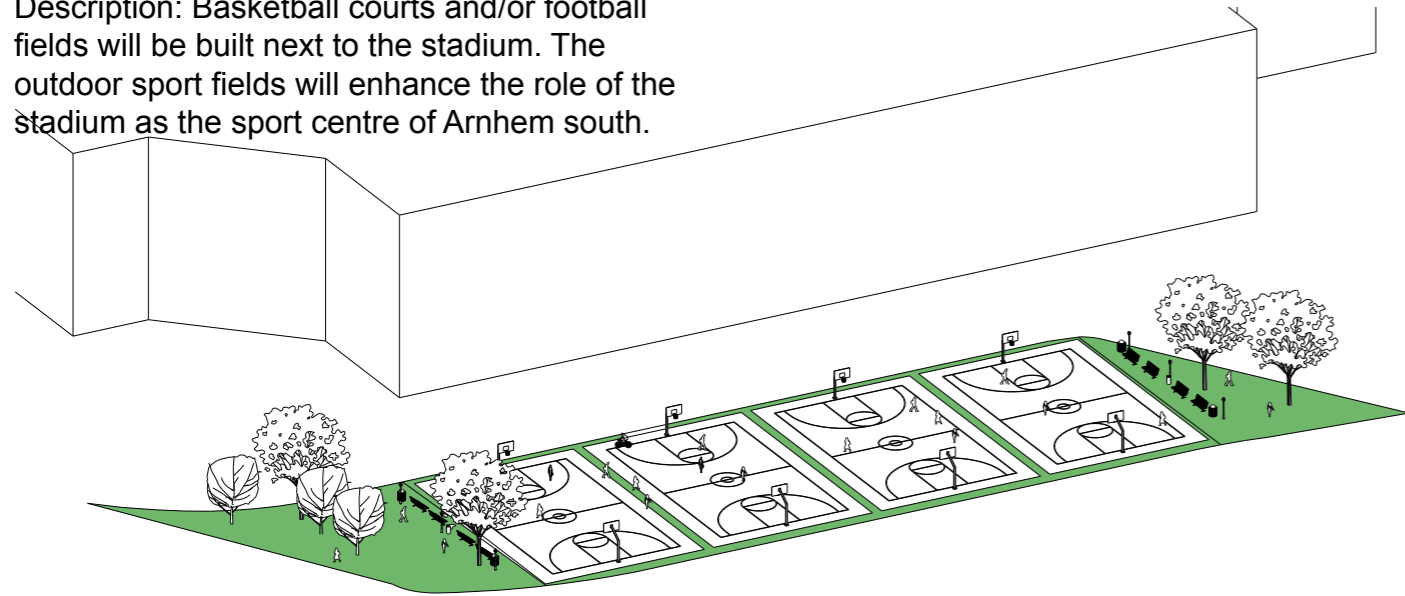
Parks and sport fields

Type 1: Sport field

Location: Near the GelreDome stadium

Characteristics: Physical activities

Description: Basketball courts and/or football fields will be built next to the stadium. The outdoor sport fields will enhance the role of the stadium as the sport centre of Arnhem south.

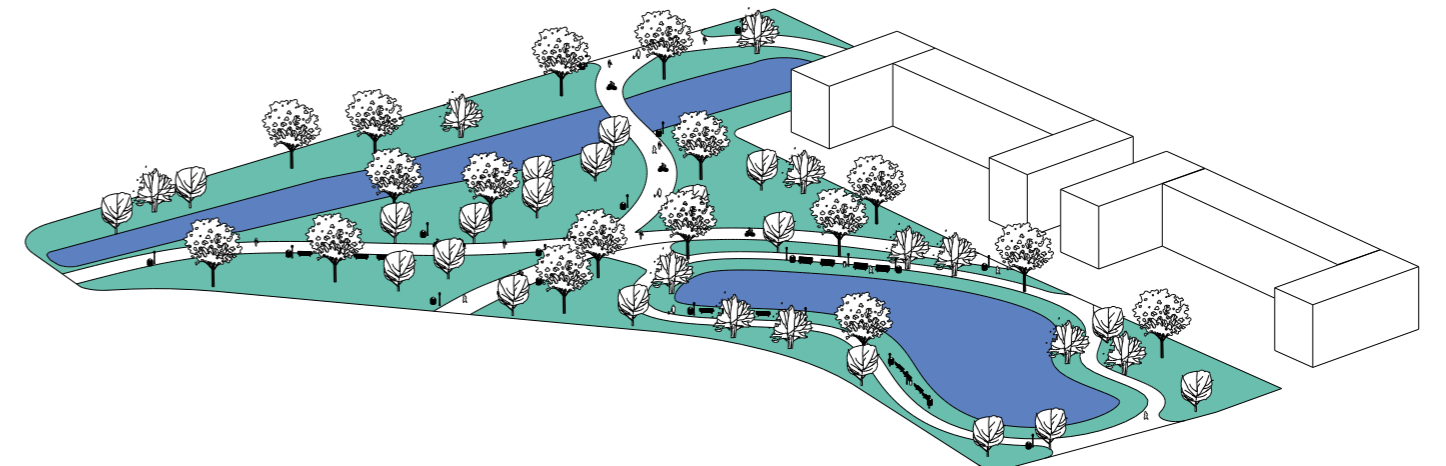


Type 2: Park

Location: Next to the intersection and connect with the green belt

Characteristics: Recreational activities

Description: The Park will be s English garden style, with trees, canal and pond. It will be a good place for cycling, jogging, dog walking or barbeque.

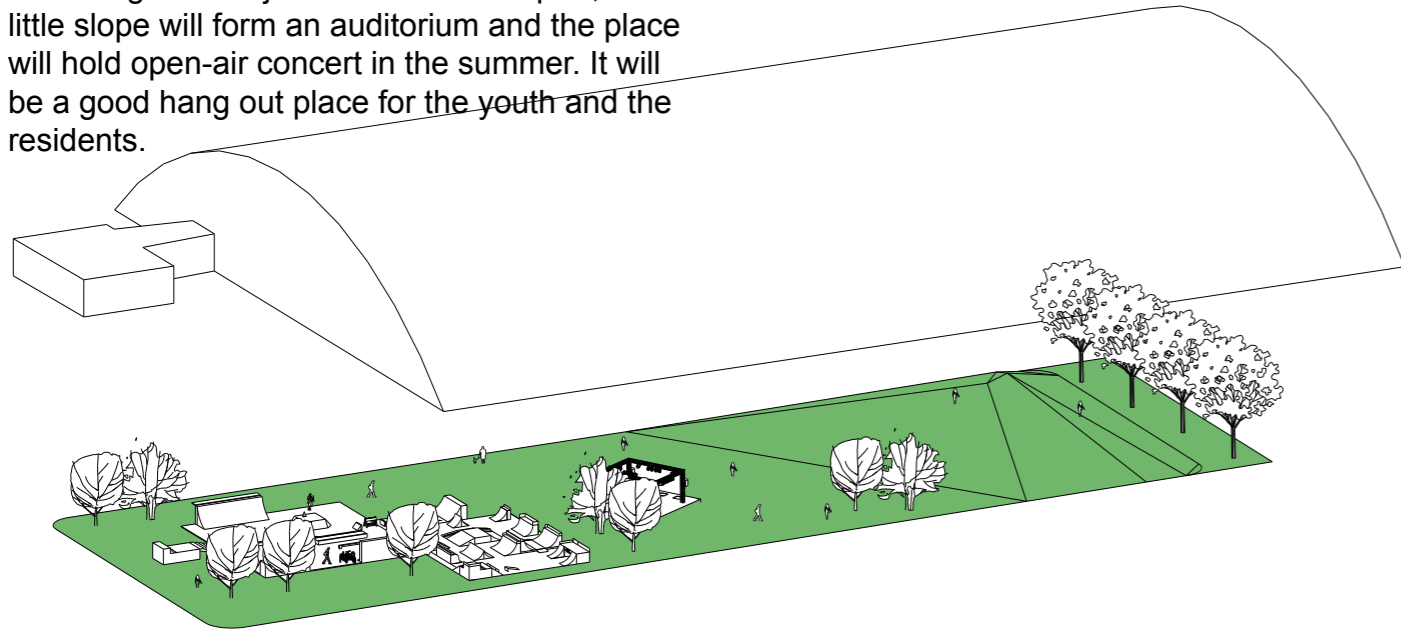


Type 3: Skate park

Location: Next to Rijnhal

Characteristics: Physical activities

Description: The skate park will locate next to the college and Rijnhal. On the north part, the little slope will form an auditorium and the place will hold open-air concert in the summer. It will be a good hang out place for the youth and the residents.

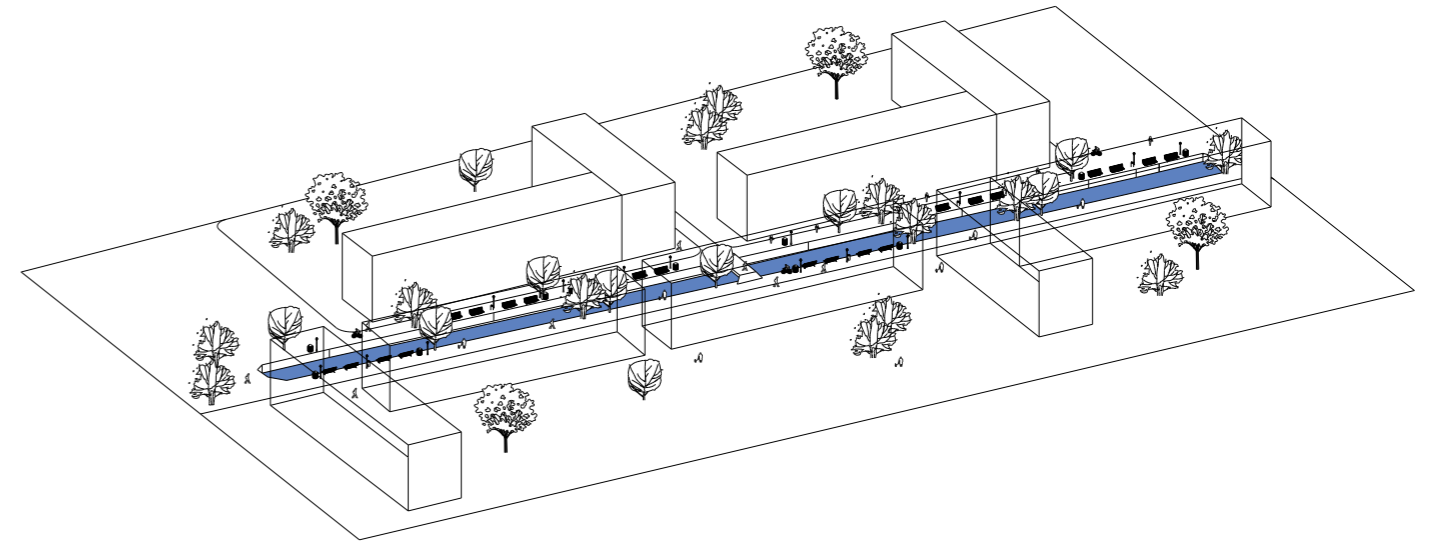


Type 4: Waterfront

Location: All the canals

Characteristics: Recreational activities

Description: The waterfront will be equipped with benches and trees. The whole canal will be a continuous urban landscape in Arnhem south centre.

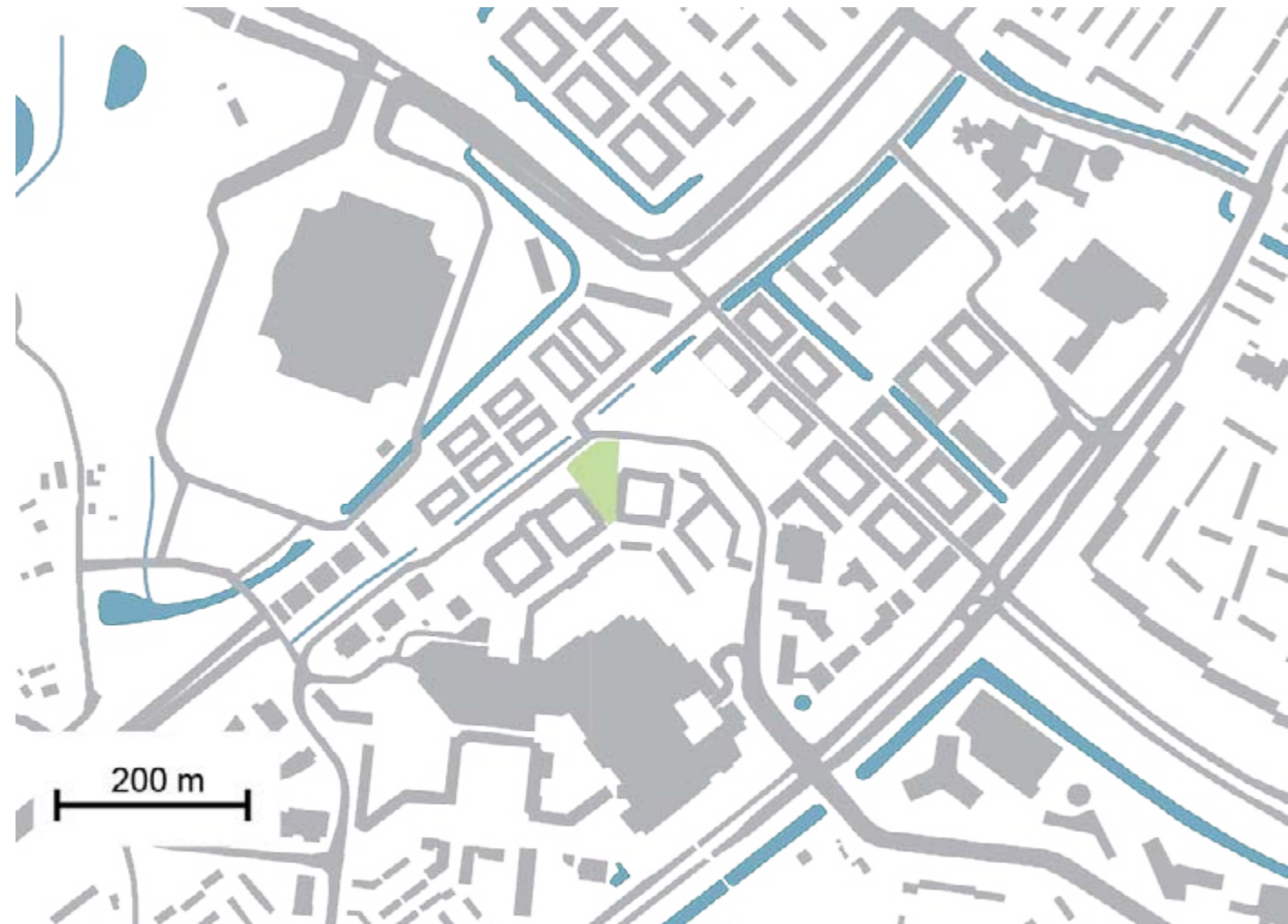
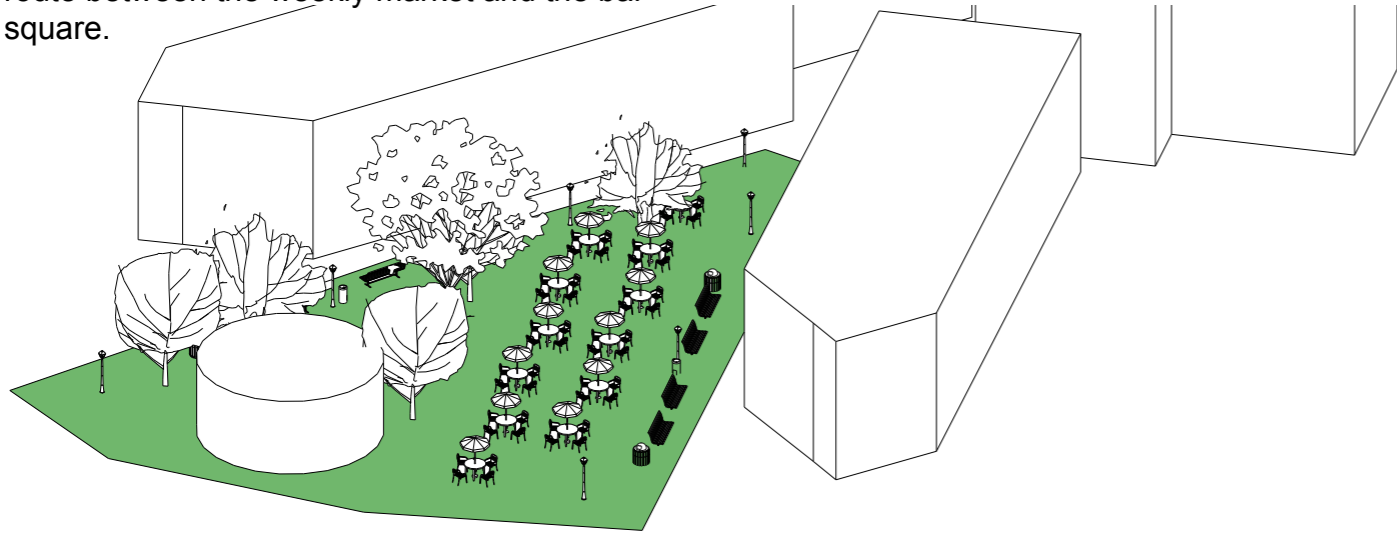


Type 5: Café corner

Location: In the existing building block

Characteristics: Social activities

Description: This area is use to be a courtyard in a building block. The building is one of the few buildings been demolished in the project. This space will be important on the pedestrian route between the weekly market and the bar square.



4.3.7 Impressions



Weekly market square



Transition square



Canal



Centre zone A

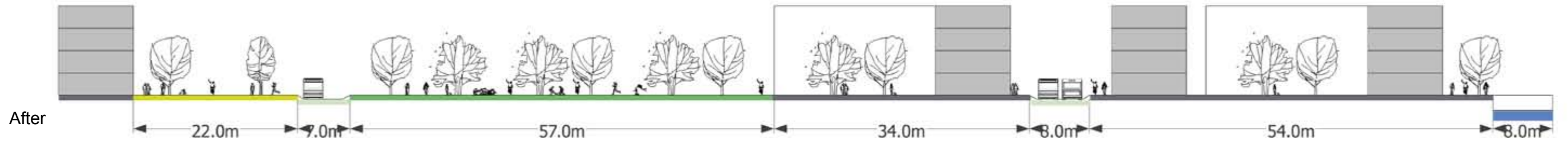


Bar & cafe square

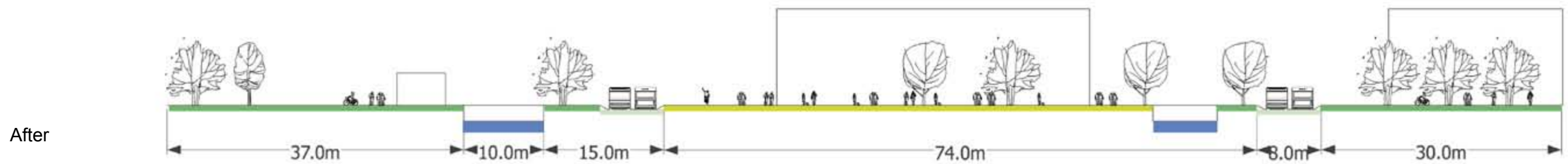
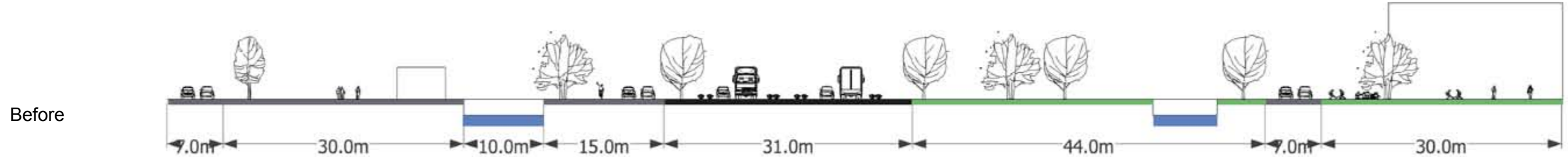


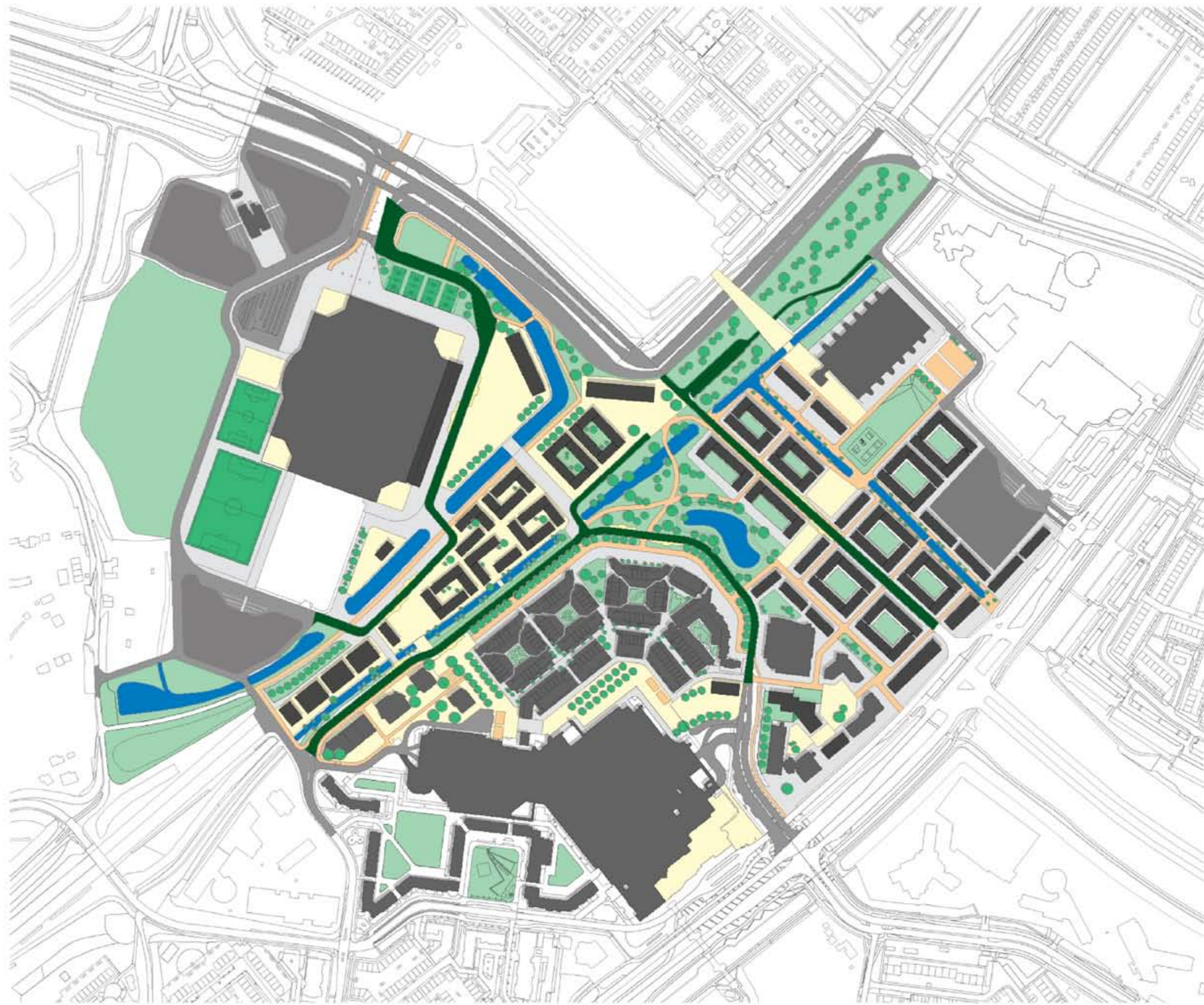
Centre zone B

Road sections--Highway N325



Road sections--Highway A325





N
↑
100 m

- New buildings
- Existing buildings
- Parking garage
- Green field
- Square
- Sidewalk
- Bike route
- Motor vehicle lane
- Bus lane
- Canal
- Tree

4.3.9 Energy

In the project, the automated parking garages works as energy buffer. The production of electricity from wind turbines or solar panels are not stable, they highly depend on the natural conditions. However, people use the energy regardless those natural conditions (Figure 4.20). Thus, if wind, sun and earth are going to be our energy resource, we need to find a way to store the energy. Collecting all the batteries on the PHEVs and use them as a big batteries for the neighbourhood is a possible solution (Figure 4.21).

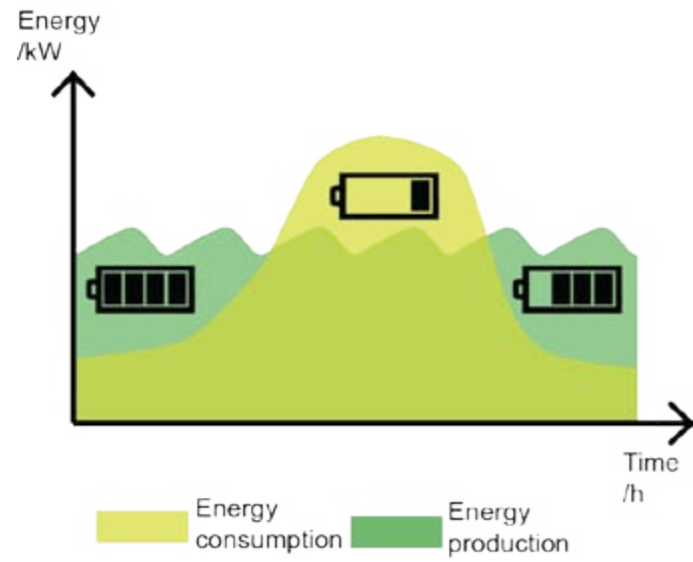


Figure 4.20 Parking garage as the energy storage

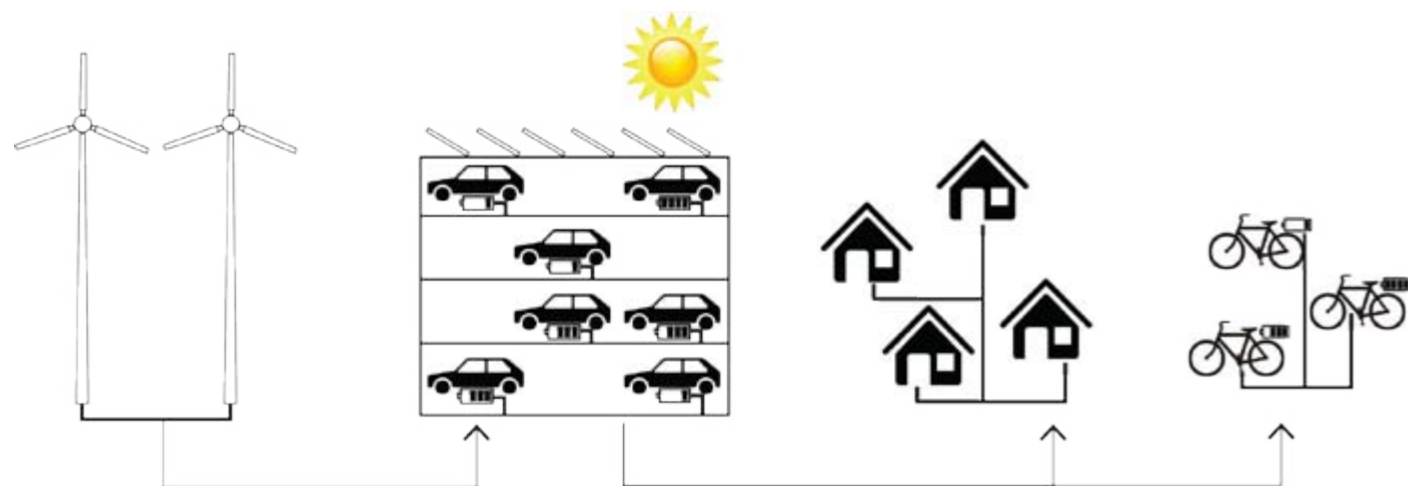


Figure 4.21 Energy store and distribution model

Applying the idea on the project, Arnhem south centre could be divided into three energy zones (Figure 4.22): west zone, north zone and south zone. West zone will have higher voltage than the other two, due to the high voltage demand of the stadium. The automated parking garages in the zones will be connected to the energy producer directly, such as the wind turbines. The solar panels on the roof and façade of the parking garages will be the second energy source. All the energy will be stored in the parking garage, and then will be distributed to each building.

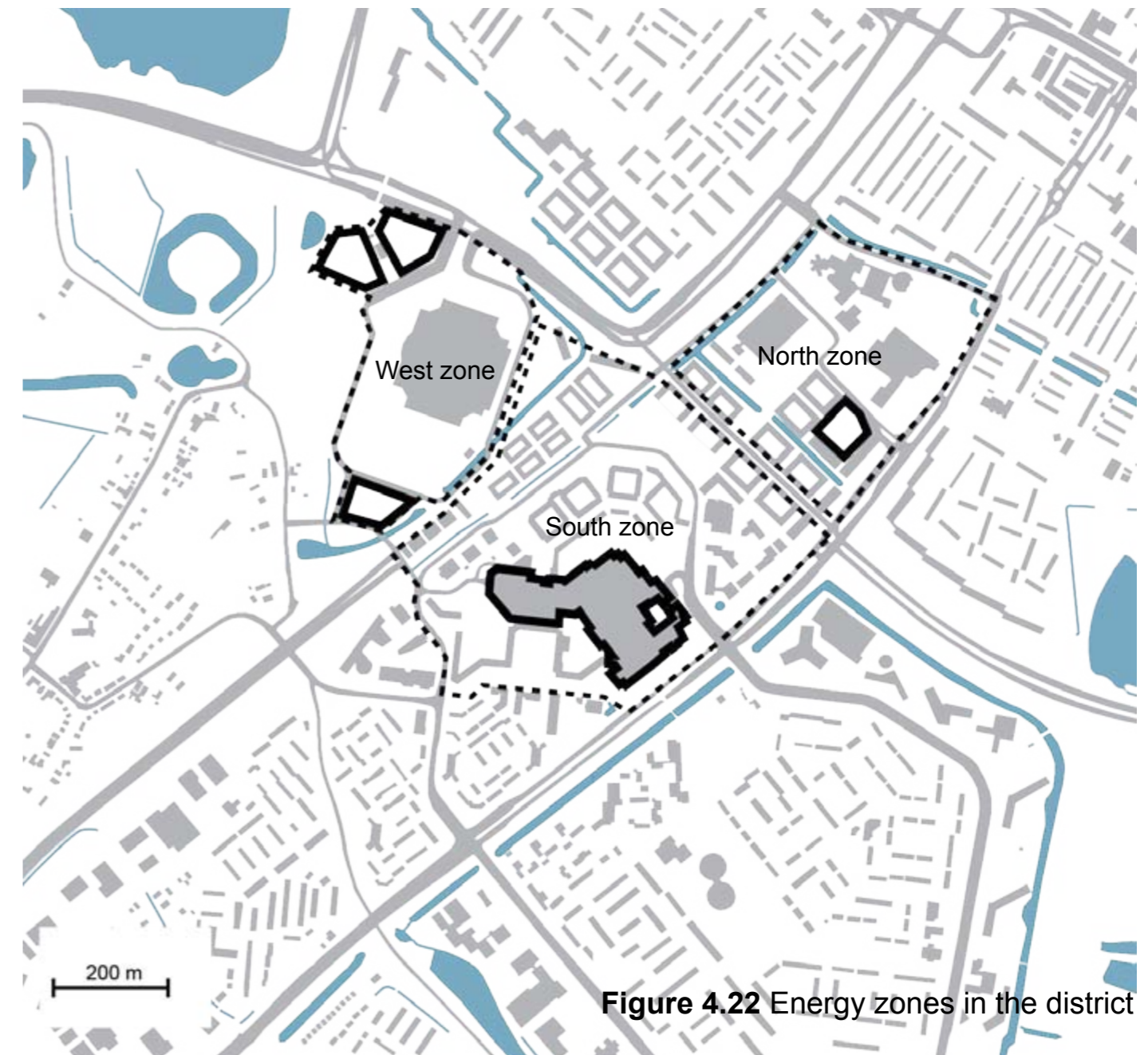


Figure 4.22 Energy zones in the district

Part 5 Evaluation and conclusion

5.1 Evaluation

LEED, or Leadership in Energy and Environmental Design, developed by the U.S. Green Building Council (USGBC) in 2000. It consists of a suite of rating systems for the design, construction and operation of high performance green buildings, homes and neighbourhoods.

'LEED certification provides independent, third-party verification that a building, home or community was designed and built using strategies aimed at achieving high performance in key areas of human and environmental health: sustainable site development, water savings, energy efficiency, materials selection and indoor environmental quality.' (USGBC, 2011)

This project achieves all the prerequisites and earns 69 points (see appendix) of LEED for Neighbourhood development rating system (USGBC, 2007). Its certification level is Gold (60-79 points).

5.2 Data

Design area: 60.2 ha
New construction area: 10.4 ha
Existing green area: 6.5 ha
Green area in 2050: 10.8 ha

Construction:
Dwelling units: 660
Residential floor area: 65820 sq.m
Business floor area: 21972 sq.m
Commercial & cultural floor area: 45427 sq.m

Parking:
Existing parking spaces: 7000
Parking spaces in 2050: 4500

5.3 Conclusion

The project starts from world oil shortage and the existing urban spatial problems in Arnhem central south area. It explores the relationship of transportation and urban planning. The purpose of the project is to assist the urban planners a case for coordination among energy consumption, traffic management and urban development. In this report, it addresses a systematic theory combining transport mode choice, travel behaviours and urban planning on different scales, and then applies the theory on site test.

The core aim of the project is wanted to be able to provide a guidance of regenerate the existing auto-oriented neighbourhood to pedestrian-oriented in Dutch urban context. With these goals in mind, this project creates a theory of adopting space and energy efficiency transport modes in urban design. In the theory part, it not only reviews existing urban plan theory, but also contributes to implement energy transition. The theory is the foundation of the project.

Arnhem central south regeneration design is built on the basis of the theory, and carries out on regional, city and district scales. It is a good example of adopting the theory on a site test. Based on the result of evaluation, the pre-review approval of the plan is achieved. It means the urban regeneration design could be feasible in reality, and the theory is efficacious.

However, the research is based on Dutch urban context, as it is addressed before, this model has its limitation. For one thing, the City-Region area could not be too large, due to the battery performance of electric cars, and the City-Region must has more than one big cities, or towns. For another thing, although the electric bikes have more advantages than conventional bikes, owing to climate and geographic limitations, cycling could not be widespread all over the world. Thus, the model is not universal, could not applied to any City-Region.

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