

Planning for resource efficient cities

Application of the Metabolic Impact Assessment tool in Stockholm and Newcastle

Patrick Galera Lindblom, Ryan Weber, Mitchell Reardon
and Peter Schmitt

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SUME – Sustainable Urban Metabolism For Europe
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Stockholm, Sweden, 2011

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Summary

Introduction

Cities today face new challenges not only with regard to fulfilling the basic requirements of a rapidly growing population but also global challenges such as climate change and the ongoing depletion of natural resources. It was in this context that the Urban Metabolism for Europe (SUME) project was conceived. SUME aimed to analyse the impacts of existing urban forms on resource consumption and to assess the future potential to transform urban areas in order to reduce resource and energy consumption. The metabolism concept applied in the project investigated the biophysical interaction between a society and its environment, by accounting resource consumption, e.g. energy, materials and land, and outputs to the environment, and linking these with various social, economic and technical parameters. The SUME project focused on those aspects most strongly connected to urban form and urban planning, namely buildings and transportation.

The development and application of a planning and evaluation method, namely, Metabolic Impact Assessment (MIA) was one of the primary tasks of the SUME project. The MIA methodology was developed by the Faculty of Engineering at the University of Oporto (Citta) and designed to assess the overall impact of a particular development proposal (policy, programme, plan or project) on the existing urban metabolism of a given urban area or region, specifically in terms of energy, land, water and materials.

This working paper is based on the results of two of the four case studies where MIA was applied in the evaluation of two urban development projects, namely, the first phase of the Stockholm Royal Seaport project and the Newcastle Great Park project. The aim of the working paper is specifically to:

- present the results obtained by Nordregio during the application of the MIA methodology in the context of the two case studies.
- compare the performance of both urban development projects and the policy and socioeconomic context of Stockholm and Newcastle and evaluate the MIA methodology as a planning tool for practitioners.

Synthesis of the case studies

The Stockholm Royal Seaport-Hjorthagen

The first phase in a three development phase project for the Stockholm Royal Seaport (Norra Djurgårdsstaden) is currently being undertaken in the area of Hjorthagen located in the city of Stockholm. Construction in Hjorthagen formally began in early 2010 and is expected to provide approximately 5,000 new apartments accommodating approximately 13,700 new inhabitants. The Stockholm Royal Seaport is a brownfield development, promoted largely on the basis of ambitious environmental goals taken by the City Administration. The project is designed to mitigate housing shortages in the inner city caused by population growth. Carbon emissions that are below 1.5 tons *per capita* per year by 2020, free of fossil fuel dependence by 2030 and the ability to readily adapt to future climate challenges are the central goals of the project.

Today, the city of Stockholm has a clear transit-oriented urban structure in which residences and commercial buildings are concentrated along the metro and light-rail lines and distinct centres are grouped around the city centre. The city is today developing inwards; from suburban areas towards the city centre. While it has experienced rapid population growth the availability of residential space has been constrained by the low volume of construction of new residential buildings and the presence of extensive 'nature and culture' protected areas.

District heating and electricity are the main energy carriers in the city. Thanks to the rapid substitution of oil by district heating and electricity, renewables have become the dominant source of energy in the city's energy system. This has been of particular importance because the residential and service sectors are most energy intensive. Surrounded by Lake Mälaren the city of Stockholm also has excellent access to fresh water.

The most obvious impact of the project in Hjorthagen is the area's radical transition from industrial to residential land use. By raising the height of the buildings in Hjorthagen, the density of the built environment will almost double relative to the average for Stockholm, while floor space per inhabitant will increase by approximately 29%. In terms of the consumption of residential energy *per capita* it is estimated to be 67% lower than the city's average. Water consumption for residences is also expected to be reduced by half from current levels through new water saving technologies and the reuse of rainwater for irrigation. The new development also implies a new approach on wastewater management in which organic material (sludge) in wastewaters is used for production of biogas.

Car use is also expected to be reduced through several measures including, among others, improving accessibility to and the enlargement of public transport, car-pooling, improvements in the accessibility of the city and neighbouring areas to pedestrians and cyclists and limits on parking places to 0.185 parking places per inhabitant, which relates to approximately half of the level of car ownership in the city. Nevertheless, the area's closeness to the city centre is viewed as a contributory factor in reducing private car transport.

In order to achieve the above-mentioned reductions in resource consumption a change in consumption habits among residents will however be necessary. This is undoubtedly viewed as one of the most important challenges faced by the project, particularly when taking into consideration the likely high levels of income of the new residents.

The Stockholm Royal Seaport also has a fundamental role to play in showcasing environmental measures that may become the norm

in future urban development in the city. This is implied not only through the promotion of new technologies but also through the creation of the structural and social basis for the establishment of new perspectives on resource consumption.

The Newcastle Great Park

The Metabolic Impact Assessment for Newcastle Great Park consists of an assessment of 1,846 homes for approximately 4,430 residents and covers 123 hectares.

Given the availability of brownfield land in proximity to the city centre or existing Metro stations, the rationale to build seven kilometres north of the city centre and without reasonable access to the existing Metro network is controversial. Yet, as the largest planned or ongoing mixed-use development project in the Tyne and Wear region, the assessment of Newcastle Great Park highlights an ongoing conflict of interest facing planners in Newcastle. While revitalisation programs are in place to redevelop inner city neighbourhoods that have succumb to partial or complete market failure (which has led to widespread abandonment) relatively little progress has been made in terms of shifting housing demand towards denser urban communities.

Newcastle has long been susceptible to out-migration to neighbouring municipalities that can meet the market demand for suburban-style living arrangements at a relatively low cost. In an effort to retain these residents, Newcastle Great Park continues to be developed out of market competition, with a view to limiting the out-migration of middle and high income residents who would otherwise seek detached and semi-detached, executive-style, homes outside the city.

The result is that the need to retain tax income by avoiding the out-migration of residents to surrounding municipalities has undoubtedly spurred the desire to build Newcastle Great Park, even though this will reinforce negative trends of resource consumption in the City. The already high level of private car dependency will grow further, just as the large living spaces coupled with the relaxed minimum energy performance requirements will

negatively impact trends of domestic energy and land consumption in Newcastle.

The Newcastle Great Park Assessment underlines the dilemma facing planners in Newcastle; despite their central locations, inner-city brownfield sites face widespread stigmatisation, manifested by low market demand, planners are thus forced to develop unsustainable housing projects to simply retain Newcastle's population.

Comparing the Stockholm Royal Seaport and Newcastle Great Park

The Stockholm Royal Seaport and Newcastle Great Park developments were conceived within completely different regional development contexts. The city of Stockholm is experiencing constant and rapidly rising levels of domestic and international migration while Newcastle continues to see a slow but perceptible decline in population terms. Contrasting local perceptions of desirable lifestyles also have important repercussions for the location and attributes of these projects. On the one hand, in Stockholm there is a strong tendency for people to demand apartments within the inner-city. The situation in Newcastle is the reverse, where neighbourhoods with the highest demand are located outside the city centre. These diverging characteristics do however go some way to explaining the completely different rationales behind the constructions of these projects.

The municipalities of Stockholm and Newcastle share the basic feature of having a rather mono-centric urban structure. The major contrast however is that Stockholm has a clear transit-oriented urban structure where development is concentrated along the metro and light rail lines, while in the case of Newcastle the metro system has not been extended in many areas, mainly in the south-west of the city. While the population density in Stockholm is higher due to its urban structure, the lower densification in Newcastle indicates the presence of sprawl and a large number of single family buildings.

The availability of water resources and the infrastructure for its distribution appear to be sufficient to satisfy further demand in both cities. Their energy systems however are very different. The main energy source for heating and hot water in Stockholm is district heating while in Newcastle the primary source is natural gas. The creation of a vast district heating is a significant advantage for new developments in Stockholm both in terms of reducing CO₂ emissions and energy efficiency. This is because renewables are the main energy source for district heating in Stockholm. In terms of the consumption patterns associated with energy by buildings, both cities are also very different mainly due to the existence of different climatic conditions.

The basic characteristics of the intervention areas are completely different. The Stockholm Royal Seaport is a brownfield development constructed on a former industrial land adjacent to the city centre while Newcastle Great Park is a green field development constructed on former agricultural land located in the outer peripheries of the city.

The spatial attributes of the intervention area in both projects can be considered as having a major role in their metabolic performance. In terms of land use efficiency the Stockholm Royal Seaport is based on the reuse and transformation of already utilised industrial land that no longer fulfilled its purpose. In contrast, the Newcastle Great Park project constructed on agricultural land sees agricultural production replaced by inefficient urban solutions but also that further land is sealed.

The location of the intervention areas also have significant repercussions on the energy consumed by the transport sector. The location of the Stockholm Royal Seaport lays the foundations for a highly efficient public transport system. Its relative proximity to the city centre makes it possible for residents to reach jobs and services by walking and cycling. Moreover, the number of parking places will be limited. On the contrary, the complete opposite is the case in respect of all of these issues in Newcastle.

The implementation of building technologies and small scale energy generation may determine levels of consumption in both projects. Buildings in the Stockholm Royal Seaport will be constructed with

ambitious energy standards and cutting edge technologies and come with devices for the on-site production of renewable electricity (sun and wind). In Newcastle the energy efficiency levels of buildings correspond only to national standards while the production of local renewable energy is rather limited.

Water consumption by households in both development projects is expected to fall below the average for each city. While technological solutions for water saving measures are similar, the use of storm water for irrigation is unique to the Stockholm Royal Seaport project. The use of the organic fraction of wastewater for biogas production is another unique feature of the Stockholm Royal Seaport. In the Newcastle Great Park project irrigation is regarded as a potential problem as house gardens may require more water than expected.

The application of MIA as a planning tool

MIA and EIA (Environmental Impact Assessment) share many features in common, mainly the basic criterion for decision making in planning as both serve as a knowledge base for decision making and the search for objectivity. MIA also complies with the objective, the alternative and the comparability criteria. On the other hand MIA and EIA are also very different not only in the choice of their components (scoping) but also in the depth and geographic scales under which each is evaluated.

MIA is restricted to a handful of elements namely energy, water, land and materials. EIA on the other hand is general and flexible in terms of the number of components evaluated which are chosen in accordance with the perceived impact of the project proposal and the sensibility of the intervention area (the area confined to the project). Energy demand assessments can be addressed in EIA but they are generally at a very general level.

The scale the impacts are evaluated at is also different in MIA, because it addresses the urban form. Specifically the study area is defined in MIA by the borders of the urban area and or the borders

given by the assessment model. In the case of EIA the assessment of impacts is, in most cases, restricted to the intervention area.

MIA is intended to be more integrative than EIA as it is based on the rationale of urban metabolism, which is to specifically acknowledge that resources have are delivered into the intervention area as inputs, are used within the system as throughputs and exit the area as outputs. During the implementation in the case studies however, the underlying complexity of the natural systems that were being investigated meant that the process of interrelating components in MIA was very limited.

The case studies also showed that, due to its level of detail and larger geographic scope, MIA requires detailed quantitative data of the study area in order to realise a comparative analysis between alternative development projects and resource consumption patterns taking place.

The practical application of MIA relies on its capacity to become a reliable and cost effective communication and decision making tool for end users, including planners, developers and the public in general. Achieving a high degree of versatility when it is applied by the institutions responsible for making impact assessments is also essential. The MIA approach partly complies with these basic requirements because it:

- captures the context (status quo, trends and strategies) of an urban area and addresses its direct and indirect impacts in relation to the context at various geographic scales in the early phases of planning.
- provides a better understanding of the challenges put forward by new development projects and identifies potential bottlenecks in the flows and stock of energy, material, water and land.
- is compatible with EIA practices. Therefore MIA and EIA could be carried out simultaneously in a complementary manner where possible.
- combines approaches from different planning disciplines such as urban, energy and transport planning into a single document.

- is a tool that seamlessly complies with current planning demands as it routinely addresses both climate change and nature resource depletion.

MIA needs however to be further developed not only in terms of its objectives but equally importantly in terms of being able to compete with other environmental accounting methods such as Life Cycle Analysis and Material Flow Analysis. This implies that the work on improving the MIA methodology should:

- provide a simpler structure when applied and reported so that it can be understood by a wider range of users including the public.
- simplify the scoping criteria for the selection of the assessment models and make them more flexible. The utilisation of qualitative methodologies should also be considered as an alternative to supplement quantitative models.
- give more emphasis to the compliance with strategies and sustainability criteria rather than focusing on the technical performance of infrastructures.
- put more emphasis on the soft aspects of metabolic processes such as consumer behaviour, culture, social integration, etc.
- put more emphasis on the reincorporation (cyclical processes) of materials, energy, land, etc.
- take more into account the cumulative effects of other ongoing urban development projects within the study area.

MIA should endeavour to become a more cost effective tool which can then be crystallised into a concise document that communicates the impacts of projects in an effective, coherent and reliable way. The synergies and differences in respect of MIA and EIA should also be carefully considered in order to avoid overlap and inconsistency. This suggests that close coordination between actors is indispensable along the entire process involved in MIA.

1. Introduction

The SUME project

This working paper has emerged out of the results obtained during the application of an impact assessment tool, Metabolic Impact Assessment (MIA). MIA was developed by the Faculty of Engineering at the University of Oporto (Citta) and applied to four case studies within a European research project entitled Sustainable Urban Metabolism for Europe (SUME). The SUME project was financed by the Seventh Research Framework Programme involving 10 partners from 9 countries led by the Austrian Institute for Regional Studies and Spatial Planning (ÖIR). The aim of the SUME project was to analyse the impacts of existing urban forms on resource consumption, and assess the future potential to transform urban building and spatial structures in order to reduce resource and energy consumption. The project started in November 2008 and was concluded in October 2011.

The outcomes from the SUME project included:

- Spatial development scenarios for Vienna, Munich, Newcastle, Stockholm, Porto and Athens which compared trends and SUME-policy scenarios.
- Development and application of a spatially-explicit urban resource flow (metabolism) model, to be tested and applied in the case study cities, accompanied by an agent-based model component to allow the simulation of urban planning decision-making.
- Development and application of a planning and evaluation method, the so-called MIA, to analyse the impact of large scale urban development projects on the overall resource performance of a city (which is focus of this report).
- Design of policies and policy tools on urban planning on the basis of an investigation of actors and planning policies and institutions relevant in

influencing the spatial dimension of urban development.

The metabolism concept applied in the SUME project investigated the biophysical interaction between a society and its environment by accounting for resource use e.g. energy, materials and land and outputs to the environment, linking these with various social, economic and technical parameters. The SUME project focused on the two aspects of the urban metabolism most strongly connected to the urban form and urban planning, namely, buildings and transportation.

Metabolic Impact Assessment (MIA) and its methodological approach

The MIA methodology was designed by a team of researchers at the Faculty of Engineering at the University of Oporto (Citta) to provide an operational instrument to assess the overall impact of a particular development proposal (policy, programme, plan or project) on the existing urban metabolism performance of a given urban area, municipality or region (Pinho *et al.*, 2011). Within the SUME project MIA was applied to the assessment of four urban development projects each corresponding to one European city, namely Porto, Stockholm, Newcastle and Vienna.

MIA attempts, specifically, to address common challenges found in these four European cities regarding resource efficiency and depletion. The MIA concept is rooted in the acknowledgement that developments or urban projects are often seen in isolation, detached from the geographical context in which they are located. MIA addresses this problem by assessing the “Metabolic” performance of a

particular development project, by identifying its likely demands in terms of energy, land, water and materials and the impact of these demands on a city's (study area)¹ carrying capacity (Pinho *et al*, 2011).

According to Pinho *et al*, 2010 (p.51), the main characteristics of the MIA are that:

- It evaluates the urban development process, from a metabolic perspective.
- It focuses on plans and projects as fundamental drivers of the urban development process.
- It explores the spatial dimension of alternative development processes.
- It address different temporal scales
- It deals with the environment in an integrated way.

As illustrated in Figure 1, MIA comprises a set of procedures divided into six stages. Each stage incorporates the main components of the urban metabolism, specifically energy, water, materials and land (Pinho *et al*, 2011).

Stage 1. Definition of the study area, intervention area and scoping

The application of MIA in a given city or urban area generally requires the availability of an overall urban metabolism model which defines the assessment of the flows and stocks of energy, water and materials and the scale of the assessment. The borders of the study area can be defined either by the scale given by an existing model or as the urban area exists in accordance with three main criteria; the nature (scale) of the potential metabolic impacts of the planning proposal, the minimum and maximum scale that provides the rationale for the metabolic model and the availability of data and the existence of sub-models. The boundaries of the intervention area are also defined at this stage, corresponding to the boundaries of the planning proposal (Pinho *et al*, 2011).

¹ The study area corresponds to the area confined within the borders of an urban area or city. The study area can also be defined by the geographic coverage of a particular assessment model.

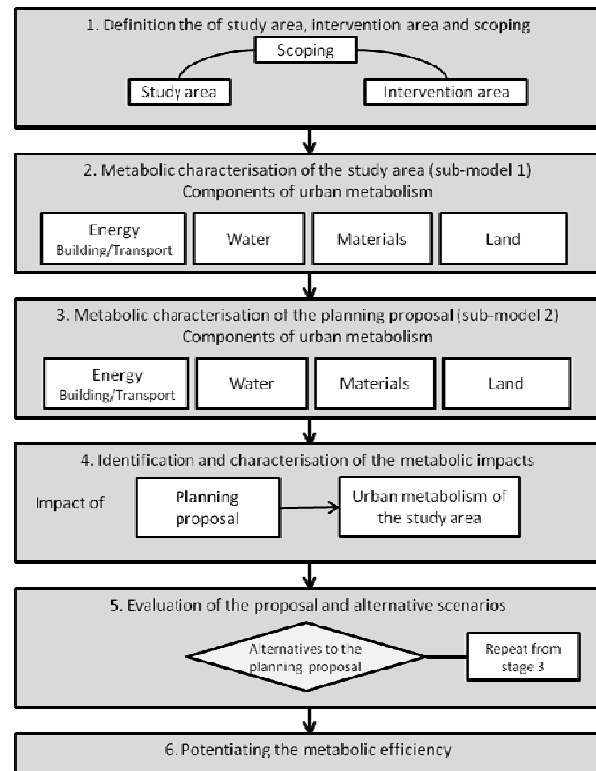


Figure 1. MIA methodological framework (Pinho *et al*, 2011)

Stage 2. Metabolic characterisation of the study area

At this stage the baseline characterisation of the study area is required in order to describe the inputs, throughputs and outputs associated with the study area, in terms of energy (from transports and buildings), land use, materials and water. This implies data gathering and further analysis and the characterisation of the study area. The goal is to explore and define the metabolic performance of the study area and identify the metabolic issues affecting the study area (Pinho *et al*, 2011).

Stage 3. Metabolic characterisation of the planning proposal

A characterisation of the likely inputs, throughputs and outputs associated with the planning proposal, in terms of flows and stocks of energy, materials, land and water is performed at this stage. This assessment should preferably match the main metabolic issues revealed in the characterisation of the study area (Stage 2). This stage can also include alternative solutions for the planning proposal such

as alternative sizes, designs, mix of functions, etc (Pinho *et al*, 2011).

Stage 4. Identification and characterisation of the metabolic impacts

On the basis of the results obtained during stages 2 and 3, stage 4 analyses the planning proposal in relation to the study area. This stage is designed to relate the forecasted inputs, throughputs and outputs associated with the implementation of the planning proposal to both the intervention and the study area. The goal is to highlight the net potential contribution of the plan (or project) proposal to the urban metabolic performance of the study area (Pinho *et al*, 2011).

Stage 5. Evaluation of the proposal and alternative scenarios

Here, the metabolic impacts of the proposal and/or alternatives are analysed in a wider perspective. This implies both an evaluation of the performance of the project proposal in relation to regional or national strategic goals as well as benchmarking the performance of the project proposal against regional, national and European indicators. This stage is, moreover, supported by an analysis of what the impact of the project on the study area would be if located in alternative locations (Pinho *et al*, 2011).

Stage 6. Potentiating the metabolic efficiency

The aim here is to support decision making and provide a sound basis for recommendations that illustrate ways to improve the metabolic performance of the project proposal as well as measures to further adapt the project proposal according to the particular urban context of the study area (Pinho *et al*, 2011).

The working paper

Aim

This working paper has three goals each addressed in individual sections. Section 2 presents the results obtained by Nordregio during the application of the MIA methodology in two urban development

projects, namely the first phase of the Stockholm Royal Seaport in Sweden and the Newcastle Great Park in the United Kingdom (UK). Section 3 provides a cross analysis comparing not only the performance of both urban development projects but also the particular policy and socioeconomic contexts of Stockholm and Newcastle.

Section 4 presents an evaluation of the MIA methodology as a planning tool for practitioners. Here, MIA is evaluated not only according to experiences obtained during its application in the context of the case studies but also in relation to the Environmental Impact Assessment (EIA) legislation in Sweden and the UK as well as against the decision making criteria applied in EIA. The goal here has been to identify both potential synergies and prevailing contrasts between EIA and MIA as a means of building the necessary foundations to assess the practical applications of MIA in planning.

Due to the cross-thematic extension of this working paper, sections 2, 3 and 4 are designed to be read either independently or in combination with each other. Section 4 however demands that the description of the MIA methodology presented in this introduction is reviewed in advance.

Data availability and methodological adjustments in the case studies

The case studies presented in the following section have been based on the MIA methodology described above. The number of components and the extent to which they have been investigated vary depending on the availability of indicators as well as on the national standards used in the production of indicators. In terms of indicators data on the turnover of construction materials was simply not available for any of the case studies.

Differences in how energy consumption and transport indicators are calculated by local authorities in the individual case study locations emerged as an important limitation in comparing both case studies and the potential to make cross analyses. In order to overcome the differences between different national indicator standards the case studies have focused attention on concrete policies and their outcomes

both at the regional and local levels in the selected urban development projects. This alternative approach significantly improved the quality of the case studies as it allowed for the comparison of the compliance of the selected projects with regional/municipal targets.

Figures for energy and water consumption have been available mainly at the national and regional level and in the case study of Stockholm, also at the municipal level. At smaller planning scales however

these indicators have not been available. Therefore, figures on energy consumption at this scale were estimated by using simple models based on land use and socioeconomic data which was available at a very detailed scale.

In the case study of Newcastle, land use data was received with a resolution at the property level while in the case study of Stockholm data was available at the smallest planning scale so-called *Basområde*.

2. Synthesis of the case studies

The Stockholm Royal Seaport (Hjorthagen area)

The area of Hjorthagen in Stockholm is being redeveloped as is currently undergoing the first of three phases in the creation of the Stockholm Royal Seaport (Norra Djurgårdsstaden). The development is being promoted largely on the basis of an ambitious environmental profile in Stockholm. The background of this urban development project is found in Stockholm's Comprehensive Plan of 1999 and 2010, the City's budget for 2008 and the Environmental Programme 2008-2011 where two major industrial areas were assigned to be transformed into mixed urban areas; of which the Stockholm Royal Seaport is one. Construction in Hjorthagen formally began in early 2010 and the first residential area will open in 2012. It is forecast that the final development in Hjorthagen will be completed in 2020. (City of Stockholm, 2008a)

The planning proposal

The development phase for the Hjorthagen area is divided into six stages; Västra, Norra I, Norra II, Norra III, Norra IV and Gasklocka III & IV. At the time when this impact assessment was made (between August and December 2010), detailed plans were in place for Hjorthagen Västra and Hjorthagen Norra I, while detailed plans for the other four areas were limited to what was illustrated in the Master Plan. Accordingly, this assessment was based on the plans for the aforementioned two areas, the Master Plan for Hjorthagen (published in May 2008), the comprehensive environmental programme for the Stockholm Royal Seaport, and other related planning material.

The new development in Hjorthagen is expected to provide approximately 5,000 new apartments with

an average size of approximately 100m² each and thus will be able to host approximately 13,700 new inhabitants. The overall height of the proposed buildings is between five and seven storeys high while the tallest building is expected to be 47. Furthermore, housing is to be made up of a mix of rental and ownership and will consist of a variety of apartment sizes and types designed to meet different needs and requirements over time (City of Stockholm, 2008a).



Map 1. Overview of the Stockholm Royal Seaport development in the Hjorthagen area (City of Stockholm, 2008a)

Building on the tradition of Hammarby Sjöstad, a nearly completed environmentally sustainable brownfield redevelopment area in south-central Stockholm, the Stockholm Royal Seaport is expected to further promote high environmental building standards in the city. The area is designed to be a mixed use district that will help mitigate housing shortages in the inner city and provide opportunities for business development. The ambition here is also to attract firms working with environmental technology innovation and indeed this is seen as a key aspect in ensuring the economic viability of the area while also enhancing the district's reputation as a leader in environmental sustainability.

Due to its proximity to the existing residential area of Hjorthagen, the new developments within

the intervention area are designed to integrate new and existing neighbourhoods into the city. The combination of nature and urbanity put forward in the project's plans is expected to ensure that the area is being developed to harness Stockholm's traditional strengths (City of Stockholm, 2008a).

Commercial and cultural activities will be concentrated in the existing buildings in the gasworks area adjacent to the local metro station in Ropsten. The new developments are planned to provide more than 77,000m² of space for public and private services, thereby providing space for approximately 4,000 new jobs. A variety of public services, including a school, pre-school facilities, libraries, culture-oriented activities and sports and recreation opportunities will be provided for the population (City of Stockholm, 2008a and Claeson, 2010).

The environmental goals of the Stockholm Royal Seaport project stem from several target documents and policies. These include: sixteen national environmental objectives, the Stockholm Environmental Programme (Vision 2030 - a world class Stockholm) and the city's 2008 budget. Efforts to promote higher environmental standards are evident in the planning material available for the project; more specifically, in the three overall environmental goals for Stockholm Royal Seaport: carbon emissions that are below 1.5 tons *per capita* per year by 2020, free of fossil fuel dependence by 2030 and the ability to readily adapt to future climate challenges. In working to achieve these goals, significant emphasis has been placed on technological innovation, reductions in energy, water and material consumption and locally-based energy solutions (Stockholm Royal Seaport, 2010).

The environmental approach in the project is clearly expressed in the in-depth programme for Hjorthagen (City of Stockholm, 2008a), which presents sixteen overall targets, grouped in three different themes; ecological, social and economic.

- Social targets
 - Good access to public and commercial services
 - A safe living environment for both adults and children
 - A good integration between existing and new infrastructure in Hjorthagen and the surrounding areas
 - Proximity to parks and green spaces and good opportunities for recreation
- Ecological targets
 - To reduce the impact on climate
 - Remediation of contaminated sites
 - A healthy living environment
 - Maintaining and developing biodiversity
- Economic targets
 - To reuse the land
 - Efficient land use
 - To promote a good business climate
- Physical-spatial targets
 - To protect and use the cultural building environment
 - A very good public transport system and pedestrian and bicycle paths

In addition, an extensive list of more precise operative targets has been set, presented in the appendixes.

The intervention area

Hjorthagen covers a total area of 123 hectares and is situated approximately two and a half kilometres east of Stockholm city centre along Lilla Värtan, a strait running between Hjorthagen and the island of Lidingö. Consisting of two *Basområde* (the smallest spatial unit for planning in Stockholm), Hjorthagen and Värtaverket, the area is located within the geographic administrative unit (*stadsdelnämnd*) of Östermalm and is bordered by the existing neighbourhood of Gärdet to the south and west. The Royal National Urban Park (*Nationalstadsparken*), a vast green space to the north of the inner city, is also in close proximity.

 Gasworks area Since the construction of Klaragasverket in 1853, the gas works were further developed until 1972. Due to the unique architectural value typical for its time Värtan Gas Works is today classified as cultural heritage monument.	 Gamla Hjorthagen The first two-storey wooden house was built in 1897 and was followed by the construction of stone buildings located in Artemisgatan. Development continued in the area until 1960. Since then almost all buildings in the area have gone through renovation.
 Abessinien The area was initially developed as housing for the workers in the gas works and the electricity plants. During the 1930's the area was further developed to improve living standards in the area. Today, the area is classified as cultural heritage because the iconic dwellings constructed during the 1930's are examples traditional functionalist architecture.	 Storängskroken The southern part of Storängskroken was used for small industries and storage. Today the area is used for commercial purposes.
 Storängsbotten Along with the Royal Tennis Hall, Storängsbotten includes an area which has been used for various sports and recreation facilities since the late 1800s.	 Värtaverket Located in the southeast quadrant of Hjorthagen, Värtaverket has hosted facilities for electrify and district heating generation since 1903. It will continue to be used for energy generation and distribution after the development of the Royal Seaport.
 Ropsten Ropsten is a traffic and public transport hub, and is the terminus of the Metro Red Line, the Lidingö Local Train and several bus lines. Therefore, it serves a main hub linking Hjorthagen and Lidingö with other areas of the city. Next to the station a park-and-ride lot with approximately 1,000 stalls is mainly used by commuters from Lidingö.	

Figure 2 Illustration of land-uses in Hjorthagen, 2010 (Photos: Ryan Weber)

Within the intervention areas there is a strong contrast between land uses. Hjorthagen includes the existing gas works and a Combined Heat and Power (CHP) plant in an area that extends from Värtan in the south and the existing residential buildings in the centre, as previously illustrated in Map 1. Directly to the south and the east, the area is bounded by Lidingövägen, while on the west it is bordered by Storängsbotten, a multi-functional recreation space that includes the Royal Tennis Hall. Hjorthagen had a population of 2,191 inhabitants in 2008 (Statistics Sweden, 2010a), which was distributed in residential dwellings that covered 37.8% of the built environment.

Currently there are 1,500 apartments in Hjorthagen with an average size of 34.2m², which is approximately 7.8m² smaller than the average apartment size in the surrounding *Basområde*. The relatively small size of apartments in Hjorthagen is related to the fact that they were originally constructed to house labourers for the local industries. In addition, the residential buildings throughout Hjorthagen have been built in different historical periods between 1897 and 1965. Thus, the built-environment of the area is characterised by the presence of culturally protected architectural styles.

The study area (The city of Stockholm)

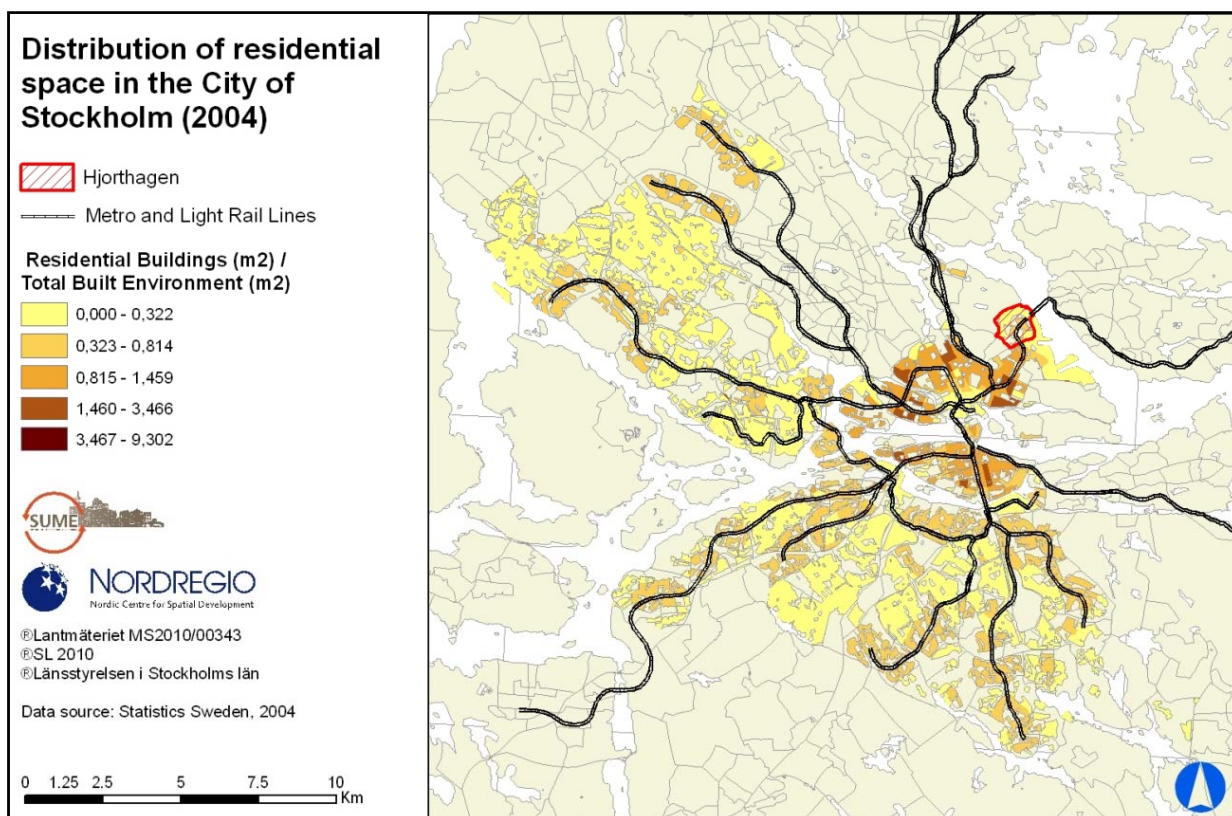
The city of Stockholm covers an area of 21,592 ha, of which approximately 13 percent (2,818 ha) is water. The city has experienced population growth of about 20% over the past 19 years, increasing from 674,452 inhabitants in 1990 to 810,129 by the end of 2009 (USK, 2011). Demographic growth is thought to be linked to the city's fast economic growth, resulting in the proliferation of jobs in the knowledge and service sectors, as well as foreign immigration and a rising birth rate.

The city's economy has gone through a transition from being industry-based to primary reliance on services and innovation. This has resulted in a higher demand for office and commercial spaces while industrial areas have been made available for new urban developments. At the same time the

availability of residential space has been constrained by a series of factors; most notably, the slow pace in the construction of new residential buildings and the lack of suitable land due to vast 'nature and culture' protected areas. Further, the rising population level has increased demands on energy, water and housing which in turn require new infrastructures and the modernisation of the existing infrastructure endowment.

The targets established by the Stockholm city plan clearly reflect responses to these and other challenges to be presented later this section. Under the vision of "of a world class Stockholm" four main strategies have been made operational (City of Stockholm, 2010a):

- Strengthen central Stockholm: by developing the central areas of Stockholm along with several strategic development areas close to the inner city. This implies expanding the inner city beyond its historic borders by growing inwards and increasing density while improving the connectivity of the suburbs to the city centre. The transformation of former industrial areas into residential areas, the expansion of the public transport network by building new light rail and metro connections are central measures here.
- Focus on strategic nodes: by creating a more polycentric settlement structure in the city. This implies the further densification and development of outer urban nodes for economic and residential purposes. This also implies increasing the accessibility to a robust range of services, culture and jobs as well as the modernisation of public transport provision.
- Connect city areas: is a response to the need to improve connectivity in the city. The construction of new public transport lines will be accompanied by the construction of infrastructure for bicycle and pedestrian travel. This strategy endorses the construction of new neighbourhoods, attractive parks and recreation areas that enhance social cohesion.
- Create a vibrant urban environment: by improving the aesthetic value of buildings and infrastructure and public service provision in relation to water, heat, electricity and waste



Map 2. Distribution of residential space in the city of Stockholm normalised by area. (Data source: Statistics Sweden, 2004)

management etc., in accordance with the city's likely level of future demand. The integration of renewable energy sources is considered central here. In that regard the city is currently expanding its capacity to produce biogas from municipal waste while also integrating biogas into the municipal gas distribution network.

Land Use

The city of Stockholm has developed since medieval times resulting in clearly identified neighbourhoods and areas of unique identity. Since the 1940s urban planning in Stockholm has been inspired by the English neighbourhood planning model, which distinguishes the city's current urban structure of neighbourhoods built along the metro lines with distinct centres grouped around a large centre with public and commercial services (Rundberg, 1989). Today the city of Stockholm has a clear transit-oriented urban structure and is developing inwards; from suburban areas towards the city centre. Signs of sprawl can however be found in the adjacent

municipalities. Moreover, the city is also characterised by a sparse distribution of buildings with roughly 25% of the land area covered by forests and another 25% by open areas of different kinds (parks, recreation areas, military sites, etc.).

The lack of suitable land for new development is particularly evident in the centre and the inner suburbs as well as in proximity to the metro and train lines. In suburban areas, sprawl has become evident, but increased demands for housing and the presence of large protected green areas simply result in more compact settlements. With many industrial activities having vacated the city, numerous former industrial areas close to the city centre have become available for new development. Many of these have subsequently been transformed into successful neighbourhoods, including Hammarby Sjöstad, an environmentally oriented brownfield development that has served as a model for new developments across the city and the Stockholm Royal Seaport project (RTK, 2010)

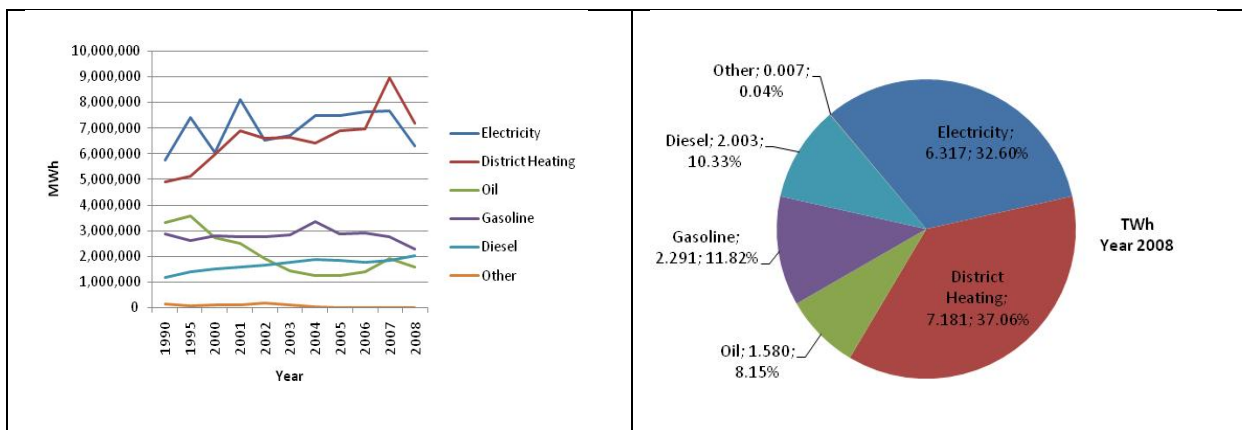


Figure 3. Energy consumption by energy carrier in the city of Stockholm. (Data source: Statistics Sweden, 2010b)

Energy

The increasing importance of the climate change mitigation and natural resource depletion issues has materialised in a rapid transition towards the promotion of renewable sources of energy and solutions that allow the city to become more energy efficient. One of the most significant measures put forward in the city has been the development of district heating. District heating has also allowed for the integration of biomass and municipal waste as a major source of energy in the city's energy system. As a result, the demand for oil has decreased while the demand for district heating has increased.

In 2008 energy consumption in Stockholm was estimated to be approximately 19.4 TWh. Covering 70% of the total energy supply, approximately 7.2 TWh and 6.3 TWh respectively, district heating and electricity are the main energy carriers supplied to the city of Stockholm. In Figure 3 it is interesting to note that the demand for district heating surpassed

the demand for electricity in 2007.

In terms of energy demand, sectors have had independent development trajectories each driven by a combination of market, demographic, governmental and technological forces. Major increases are noted in the private services sector. In contrast, the consumption of energy by the industrial sector has decreased.

These energy-related developments in Stockholm clearly reflect the strategic goals stated both in the city's comprehensive plan and energy plan. Aiming at further reducing CO₂ while securing energy supply the following strategies have been set (City of Stockholm, 2008d):

- Find alternative sites for new energy plants with sufficient distancing from residential areas.
- Further build the distribution network of electricity and gas underground.
- Further develop the district heating network and capacity and increase the number of connections

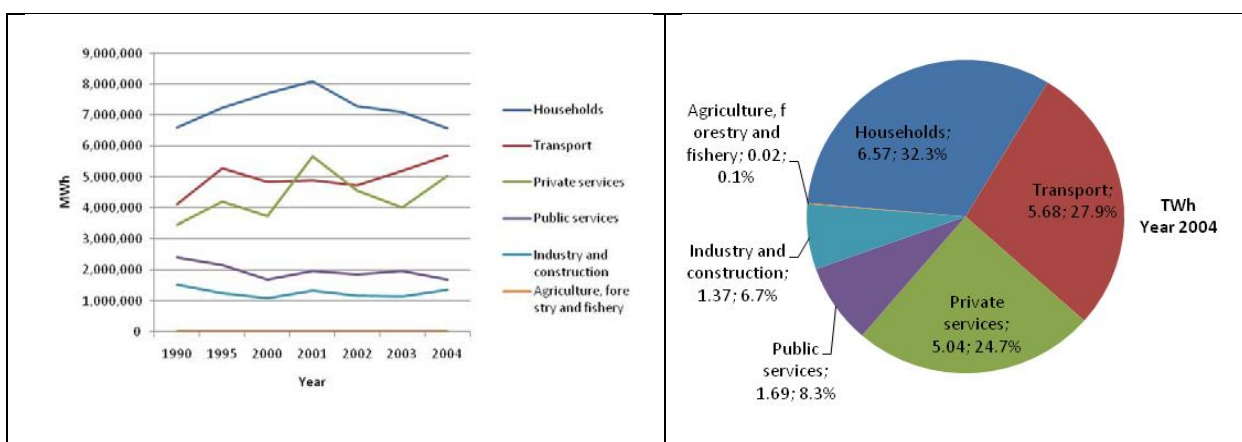


Figure 4. Energy demand by sectors in the city of Stockholm (1990-2004). (Data source: Statistics Sweden, 2010b)

- Further expand the production capacity and the use of district cooling
- Increase the generation of energy from renewable sources such as biomass and biogas and promote a readiness to embrace alternative energy sources such as solar panels, wind energy and geothermal energy.
- Establish a dialog among all actors in the building sector in order to promote and create greater awareness of energy efficiency in relation to buildings.

Buildings

The total energy consumption of the built environment (households, services and industry) in the city of Stockholm is approximately 14.66 TWh (2004 levels) or 72% of the total energy demand. Households and services are the most energy-intensive sectors in Stockholm. Despite a significant population growth in Stockholm energy demand in

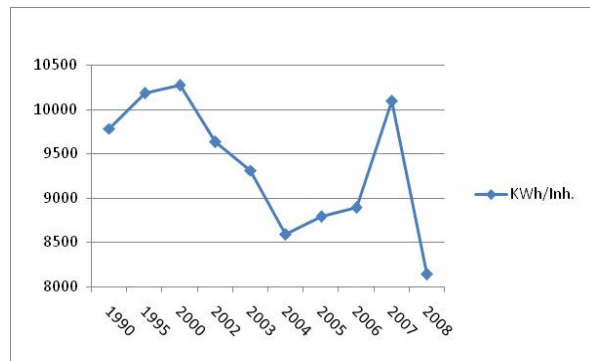
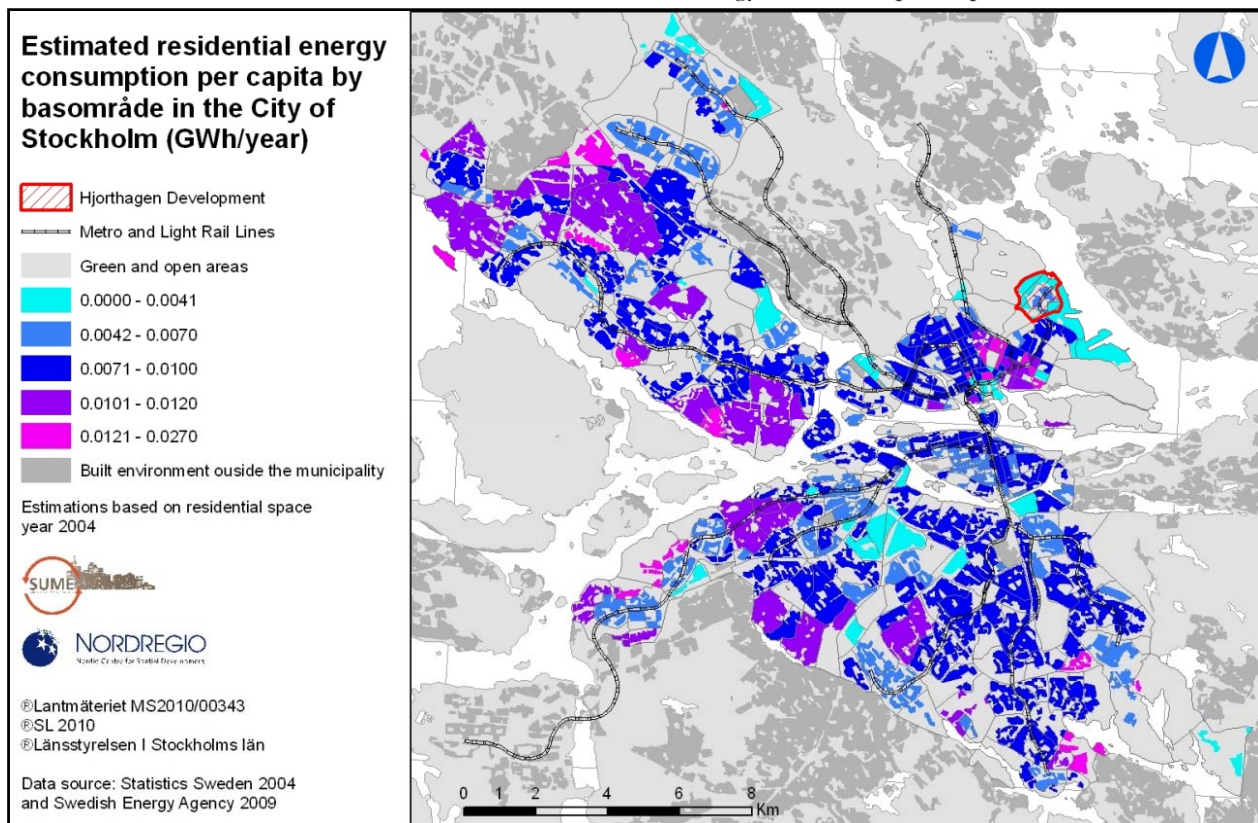


Figure 5. Yearly residential energy consumption per inhabitant in the city of Stockholm. (Data Source: Statistics Sweden, 2010c)

the residential sector has not however increased. By 2004 district heating corresponded to 66.1% of the total energy demand from households while electricity and oil corresponded to 23.5% and 19.7% respectively.

Per capita energy consumption has declined from 9.7 MWh in 1990 to 8.1 MWh in 2008 (Figure 5). Energy demand *per capita* varies however in



Map 3. Estimated residential heat and electricity consumption *per capita* by *basområde* in the city of Stockholm in GWh/year (Based on standard calculations of average energy consumption by m² by building type and age). (Data source: Statistics Sweden, 2004; and Swedish Energy Agency, 2009b)

accordance with several factors, mainly the floor area per inhabitant. This implies single family homes and wealthy households are generally more energy intensive. As outlined in Map 3 major energy consuming residents in Stockholm live mainly in the north-eastern suburbs dominated by single family homes. In the city centre intensive energy consumers are located in Östermalm where wealthy households are concentrated.

Figure 6 shows that, up to 2004 energy demand for dwellings in multi-storey buildings decreased by 18% (1.22 TWh) since 2001, and the demand for single family houses decreased by 22% or 294 GWh over the same period. By 2004 more than 76% of the total energy supply to multi-storey buildings was transmitted by district heating. In contrast, energy consumption in single family homes was predominantly electricity-based (69%) while district heating accounted for only 10% of the total energy supply.

While the reduction in energy consumption of dwellings in multi-storey buildings has been related to the expansion of district heating, the reduction in energy consumption in single family houses is the result of the evolving predominance of heat pumps which are cheaper and easier to install than district heating installations (Swedish Energy Agency, 2009).

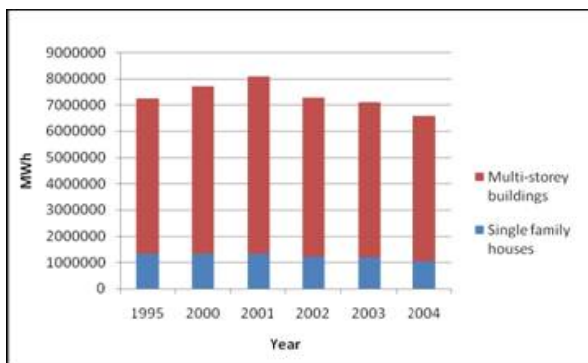


Figure 6. Total energy consumption of multi- and single family houses in the city of Stockholm (1995-2004). (Data source: Statistics Sweden, 2010b)

Transport

By 2004, the transport sector was, after the residential sector, the largest energy consuming area responsible for 27.9% of the total energy consumption in the city (5.68TWh). Figure 7 shows

that 59% (3.36TWh) of the total fuel used by the transport sector is gasoline; followed by diesel with a share of 30% (1.69TWh). Electricity is also an important energy carrier with a share of 11% or 0.63TWh (Statistics Sweden, 2010b).

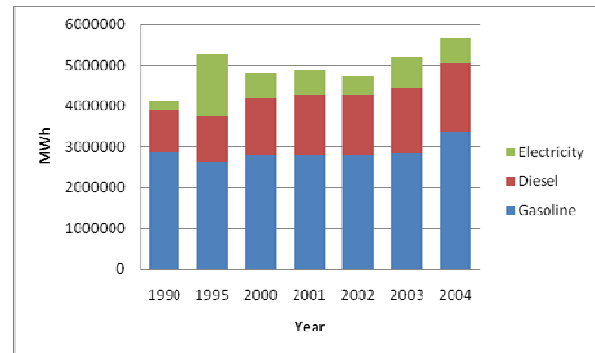


Figure 7. Energy consumption by the transport sector in the city of Stockholm between 1990 and 2004. (Data source: Statistics Sweden, 2010b)

Between 1990 and 2004 the demand for energy by the transport sector increased by 38% (1.56TWh). The demand for diesel has been a major contributor to this increase which corresponds to 0.69 TWh/year (68%). Increases in gasoline demand are recorded for the same period to 0.48TWh (17%). From 1990 to 2004 the demand for electricity by the transport sector increased 0.4TWh (165%) which has fluctuated from year to year with its highest peak in 1995 (Statistics Sweden, 2010b). These increases in the demand for gasoline and diesel are directly related to the growth in the number of cars in Stockholm, which in turn is a function of both the increasing population and economic growth.

Private car ownership has remained relatively steady in the city of Stockholm since 2000. In 2009 299,982 cars were owned by individuals living in the city. This amounts to an average of 0.364 cars per person (Statistics Sweden, 2010d). Table 1 on the next page shows that the private car is the predominant mode of transport in the Stockholm region with a share of 47%. Nevertheless, the population of Stockholm makes approximately 2.8 trips *per capita* each day (Population between 12 and 84 years) (Modig *et al.*, 2005).

In terms of trips in and out of the city centre, public transport has remained the dominant mode over the past thirty years. This dominance has been

strengthening in recent years thanks to the ongoing development of the public transport infrastructure; and the introduction of congestion charges for travelling in and out of Stockholm's inner city since 2007.

Table 1. Transport characterisation of Stockholm, 2004. (Modig *et al.*, 2005)

Transport mode	Modal split	Average distance per trip (km)
Pedestrian	15%	2.6
Bicycles	6%	5.1
Car	47%	13.5
Public transport	30%	13.6
Other	2%	14.9
Total	100%	11.4
Mobility rate	2.8 trips per inhabitant and day	
Private car ownership	364 vehicles per 1000 inhabitants year 2009 (Data: Statistics Sweden, 2010d)	

Water

The city of Stockholm has access to an ample supply of fresh water. Water is not only a resource for consumption in Stockholm but also highly important in terms of its cultural and recreational value for both residents and tourists.

In addition to securing the supply of drinking water, other priority areas are also mentioned in the city's comprehensive plan of 2008. One of the most important long term goals is to prevent the risk of sea water entering Lake Mälaren due to rising levels in the Baltic Sea. Another priority is to create enough capacity at the storm water infrastructure so that it can support loads caused by increasing population and climate change.

Despite 10.6% population growth in the city between 1997 and 2007, water consumption in the Stockholm city distribution area (Stockholm and Huddinge municipality) has been relatively stable since at least 2002 (peaked at 106.8 million m³ of water in 2008).

Water losses correspond to approximately 25% of gross water consumption. There has been an increase in water loss within the collection and distribution infrastructure network, while the net water demand (total annual distribution) has

decreased (Figure 8). According to the water company in Stockholm (*Stockholm Vatten AB*, 2010), the most water-intensive sector is households as this sector consumes approximately 90% of the net water demand or 200 litres per day *per capita* (exclusive water losses) while the remaining 10% is consumed by other sectors, mainly services.

Wastewater is treated together with the wastewaters from the seven other municipalities². Wastewater generation in the Stockholm catchment area was 132.5 million m³ in 2009. The treatment of storm water takes place through a LOD process (a Swedish acronym for local storm water treatment). This implies that storm water is treated within proximity to its initial collection point and is not mixed with the central sewage collection network. According to the Stockholm City Council (2008c), only half of the surface water from precipitation is treated prior to deposition in local lakes and streams. Therefore, policy on storm water in Stockholm is tailored towards the purification of storm water, but also to prevent its contamination.

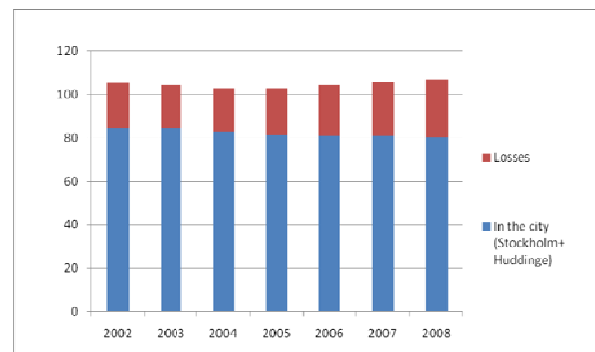


Figure 8. Annual water distribution and losses in the Stockholm distribution area. (Data source: *Stockholm Vatten AB*, 2010)

Evaluation of the impacts

Land use

The plans for the Stockholm Royal Seaport development emphasise land-use efficiency by transforming poorly exploited industrial land into a mixed area with relatively higher densities. Here, social and environmental considerations have been

² Stockholm, Huddinge, Haninge, Nacka, Tyresö, Järfälla, Sundbyberg and Ekerö.

promoted. Qualitative aspects related to the perception of the area are central to the process of designing infrastructures. Hjorthagen will include the provision of additional cultural, recreational and commercial spaces, which are intended both to improve life quality but also to attract visitors. Moreover, green areas not only serve recreational and aesthetic purposes but are also intended to serve as biotopes and green corridors for *fauna* and *flora*.

The most obvious impact in Hjorthagen is a radical transition from industrial to residential land use. This implies that approximately 48 hectares of industrial land will be transformed. The only industrial area remaining will be the CHP plant of *Värtaverket*. According to the plans, the developments in Hjorthagen comprise approximately 5,000 apartments that will be home to 13,700 new residents. This suggests that a total of approximately 603,524m² of residential floor space may be added to the intervention area. While the amount of non-residential floor space will total roughly 77,523m², with 14,192m² are planned to host schools and day-care facilities.

49.6m² per resident, approximately 29.4% more space than the city's average of 38.3m². Higher density of residential floor space will be achieved through the construction of taller buildings which will have at least five to seven storeys, the tallest being 47 storeys high. In contrast, the current buildings in the surrounding areas in Hjorthagen are generally three storeys high.

By comparing Figure 9 and Figure 10 it is possible to confirm the denser character of the new development in Hjorthagen relative to the rest of the city. However, the new buildings will be surrounded with alleys, trees, local parks and green strips which will create a more heterogeneous and harmonious environment. Nonetheless, if the areas surrounding Hjorthagen are counted, particularly the adjacent areas in the north and the west, it is evident that the new developments are privileged in having direct access to large open spaces and natural reservoirs. It is also worth noting that 12% of the intervention area will remain zoned as industrial, comprising, primarily, the CHP plant of *Värtaverket*.

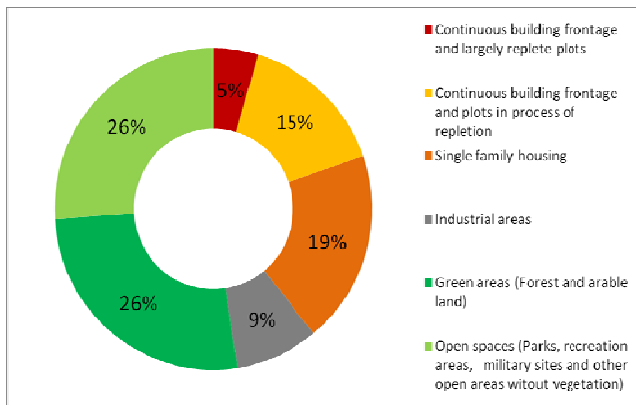


Figure 9. Land uses within the study area. (Data source: *Lantmäteriet* 2010)

The distribution of the built environment (Land covered by continuous building frontage, single family houses and industrial areas) in the city of Stockholm is less dense than in the detailed plans for Hjorthagen. *Per capita* consumption of the built environment (inclusive of open areas) in Hjorthagen will be approximately 67m² per inhabitant, compared to 171m² in the city as a whole. The new developments will provide an average floor space of

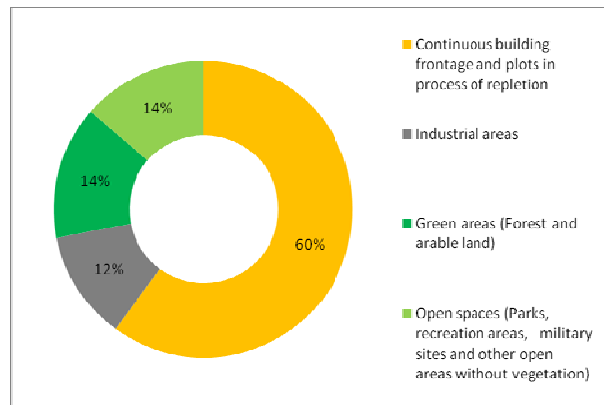


Figure 10. Land uses within the project proposal. (Data source: *Lantmäteriet* 2010)

Energy

Buildings

The goal set for residential energy consumption for the Stockholm Royal Seaport is 55kWh/m² per year, specifically 40kWh/m² of heat and 15kWh/m² electricity. Energy savings in the new buildings in Hjorthagen are intended to be achieved through the implementation of new building standards and

techniques as well as measures aiming at changing the energy consumption habits of residents.

Hjorthagen's residential building standards imply the utilisation of energy efficient wall and window insulation, heat pumps for residual heat recovery, as well as reflective windows and shields. The use of geothermal heat pumps in combination with heat collection from facades will also play an important role in saving energy.

Further, the buildings will be designed to generate at least 30% of their own energy consumption from renewable energy technologies such as small scale wind and solar installations. Should a building produce additional energy, the excess supply will be fed into the local power grid. As is the case with water, electricity and heating in each apartment will be monitored individually, aiming at inducing consciousness about energy consumption as well as providing a more accurate billing for each dwelling (Claeson, 2010 and City of Stockholm, 2010a).

On the basis of the standard values on energy consumption in residential and non-residential buildings, a total residential floor area of 602,524m² and a non-residential floor area of 77,523m² is expected for the Hjorthagen area. Based on these approximations the yearly energy consumption is estimated to be approximately 36.8 and 7.6 GWh respectively (More details about the calculation are available in Annex I). Thus, the total energy consumption of the new developments in Hjorthagen can be estimated to be at least 44.4 GWh. This may imply an increase of only 0.3% of the energy consumed by the built environment (households, services and industry) in Stockholm relative to 2008 levels (14.68TWh). In terms of the consumption of residential energy *per capita* it is estimated that a consumption 67% lower than the city's average from 2008, specifically from 8.1 to 2.69MWh per year. In terms of heat consumption for residential floor space this could be reduced by roughly 74%.

An increase of 0.3% in total energy demand may not appear to be placing a major burden on the already existing infrastructure, especially if energy efficiency is improved throughout the city as

expected. The challenge instead resides in the fact that the current energy infrastructure in the city is not optimised to the character of future electricity demand, particularly in terms of the distribution of the population and businesses. Moreover, the transmission grid must be further adapted to incorporate small scale generation from renewable energy sources and energy efficient technologies (RTK, 2010). In order to address this challenge the Stockholm Royal Seaport project incorporates a pilot project in which *ABB* and *Fortum* are developing a smart grid. The goal is to integrate small decentralised energy systems in the area into the city's grid as well as to increase the overall efficiency of the grid (Claeson, 2010).

The extensive district heating supply system in Stockholm is connected to the vast majority of the city's housing stock including the area covered by the Stockholm Royal Seaport. The capacity of the current district heating and CHP plants will be enlarged and supplemented by new plants in both current and new locations. One example is the plan to expand the capacity of the CHP plant run by *Värtaverket*, by 1,800GWh district heating and 800GWh electricity from biomass. The long term demand for district heating is, however, expected eventually to stagnate due to the adoption of energy efficient solutions in buildings.

Transport

In terms of transport the Stockholm Royal Seaport project aims to curtail the demand for private cars as much as possible. To this end several measures will be implemented, including, improving accessibility, expanding public transport options, car-pooling, imposing limits on parking places and improvements in accessibility to the city and neighbouring areas for pedestrians and cyclists. Nevertheless, by making travel plans available at schools and work places, and promoting various 'information campaigns' residents and employees will be encouraged avoiding car use. An additional measure is a limit of 0.5 parking places per household or 0.185 parking places per inhabitant. Considering that the car ownership in the city is 0.364 cars per capita, this measure alone is expected

to lead to significant reductions in car ownership and transport in the area.

According to assessments made in connection with the new developments in Hjorthagen (Grönmilj, 2010), the new development area is designed to provide a relatively even distribution of traffic. When the first phase of the Stockholm Royal Seaport is finalised in 2020, the addition of 2,000 visitors per day to the population of 13,700 inhabitants and 4,000 workers is expected to generate approximately 50,360 trips each day in Hjorthagen (2.8 trips per resident and 2.0 for workers and visitors per day has been applied). Currently however, a lower car traffic rate of approximately 8 to 19% lower relative to the rest of the city is used for transport assessments for the Stockholm Royal Seaport development.

A reduction of 19% on car trips may suggest that the modal split for cars may thus be reduced from 47% to 38%. This implies a reduction in car trips to 19,136 which corresponds to a total energy consumption of approximately 200,938 kWh per day, if multiplied by a trip length of 13.5 kilometres (in Table 1 previously presented on page 19), an average consumption of gasoline of 0.086 L/km and an energy content of gasoline³ by 9kWh/L. This goal could be considered realistic due to the lower availability of parking place per household relative to the rest of the city, which can result in reductions of up to 10%. Moreover, the closeness of the area to the city centre may also play an important role in that respect as it may stimulate walking and cycling for daily transport to workplaces and schools.

Public transport will also require increased capacity, as it is likely that more than 18,000 additional trips may be added on a daily basis. Therefore, a key element in the development's public transport system is the city's tram network (Spårväg City), which is initially planned to connect the southern parts of the intervention area (Phase II and III) to the city centre and Ropsten. For Hjorthagen specifically, two alternatives for the public transport

have been proposed, the first one, comprises of assigning four new bus routes, while maintaining the two already existing in the intervention area. The second consists of a new tram line which could be an extension of either the tram line to Lidingö (*Lidingöbanan*) or the City Tram (*Spårväg City*). This second option may improve accessibility to the western blocks of Hjorthagen due to the efficiency of trams in terms of travel time and frequency, while also reducing congestion problems related to road traffic. (Grönmilj, 2010)

Today, the main access point to the Stockholm Royal Seaport is Lidingövägen which is currently heavily congested along with other alternative roads in the area. This situation is already acknowledged and therefore addressed through the construction of Norra Länken which will be an underground highway that will connect the Stockholm Royal Seaport to the major road networks in the city.

Generating a further reduction in terms of car use by residents as well as visitors is likely, however, to be challenging given the expected income levels of a large proportion of the new residents in the area (This is highly likely given that the high anticipated cost of properties). This implies that the impact of fees and charges on car ownership and use may have a limited influence on residents and be insufficient to force them to embrace a car free lifestyle. Therefore, emphasis on informative measures will play a fundamental role in the achievement of the project's goals.

Water

The total daily input of water for the new residential buildings in Hjorthagen has been estimated at 100 litres, per resident, per day. A series of measures will be used to maintain domestic consumption levels at that level. Most notably here is the plan to reuse storm water for the irrigation of green spaces, mainly through passive systems in which storm water flows with the help of gravity through green areas into ponds and natural water bodies. The need for pumps for the transport of this storm water is thus minimal, though where required, pumps will transport the storm water while being powered by solar energy. Freshwater consumption in the new buildings is

³ Karlsson I. and Johansson A. (2009) *Beräkningsmodell för bensin respektive diesel förbrukning per kommun*. Statistics Sweden.

expected to be reduced through technical devices such as air mixers in shower and tap outlets, water efficient toilets, other appliances and smart monitoring systems (Claeson, 2010).

A daily water consumption of 100 litres *per capita* suggests a total residential consumption for the new developments of at least 1.37 million litres per day (1,370 m³), an annual consumption of approximately 500,050m³ of fresh water. On the basis that domestic water represents up to 90% of the total water consumption the total increase in water demand for the area can be estimated to roughly 555,610m³.

The water supply system in the city of Stockholm is well-developed and can be viewed as having the capacity to satisfy further increases in demand. More recently, the water distribution system has been further developed such that it is now able to join the main water supply networks in the region. This has improved the reliability of the supply system and reduced the costs associated with water distribution. Nevertheless, the city of Stockholm is privileged in having good access to vast water resources that can sustain larger populations. Therefore, the creation of no new waterworks facilities is foreseen in the near future. An increased capacity may however be needed at the existing waterworks facilities currently supplying the city in order to meet future water demand (RTK, 2010). In this regard, the expansion of the current facilities will aim to further improve water quality.

Against this background the increase in demand of 555,610m³ per year may represent a very small fraction of the water consumption in Stockholm. The current waterworks facilities may thus be considered as having the capacity to sustain the water demand generated by the new developments in Hjorthagen.

The generation of wastewater in volume is likely to be similar to the demand for fresh water. However, a common feature of the apartments in the Stockholm Royal Seaport project is the presence of grinders installed in kitchens. This feature will allow the transport and collection of organic waste through the wastewater collection system. For the developments in Västra and Norra I the organic waste from grinders will be collected by the current

wastewater collection system in the city and transported to the treatment plant in Henriksdal. The reason for collecting food waste residues is the ambition to recover energy and nutrient content from food waste for the production of biogas and nutrients for agriculture. For the following developments in the intervention area, six other options for the collection and process of food waste from grinders are under discussion (Claeson, 2010). This solution particularly addresses the City's strategic goal to increase biogas production from organic residues.

The wastewater treatment systems in Stockholm may also have the capacity to sustain the increased load caused by the new developments in Hjorthagen. The challenge here however resides in adapting the systems for wastewater management to the new technologies applied in the new buildings. The option of using the current wastewater infrastructure for collecting food waste may imply, in the long run, the need to increase the capacity to process organic sludge for biogas production in current treatment plants. This could be considered likely as households in other areas of the city may also install grinders for the disposal of food waste. A second option under discussion here is the construction of independent networks, for instance for the separation and collection of urine. This solution is however challenging particularly at the local level, as new pipelines and containers will be required in the area. Due to the fact that underground, the development area is already overcrowded with pipes of different kinds, it will be very difficult to find further room for the construction of the required infrastructures.

Alternative scenarios and further implications

Alternative scenarios

Within the city centre there is insufficient land available to construct new urban developments on the scale of the Stockholm Royal Seaport project. Such possibilities do exist in the outer suburbs but even here numerous hindrances remain. Despite the fact accessibility to the power grids, district heating networks, water supply and wastewater networks in

the city of Stockholm is good, building in other locations may negatively affect the metabolic performance of the project.

The location of the Stockholm Royal Seaport plays an important role in terms of energy supply from district heating. The fact that the *Värtaverket* CHP plant is located within the development area brings significant benefits in terms of achieving energy savings. This is because the buildings in the area will reuse the residual heat from district heating water. Thanks to the low energy demand of buildings in the developments it is possible to use district heating water with lower temperatures, as is the case of the water that is pumped back into *Värtaverket* (Claeson, 2010).

The location of the Stockholm Royal Seaport project will have its major role in terms of the city's transport network. According to Table 2, the reallocation of the project proposal to the inner or outer suburbs may increase transport by at least 35%. This pattern can be explained in the fact that Stockholm is a mono-centric urban region. Nevertheless, given that car use increases in proportion to the distance to destination, and the fact that the access points to the city centre are currently congested, it is possible to conclude that the reallocation of the project proposal to the suburbs may worsen the congestion prevailing in the city's main access roads.

Table 2. Difference in energy consumption by car transport in different transport zone in Stockholm relative to the city centre.

Transport zone	Average distance per day per person (km) (Modig <i>et al</i> , 2005)	Difference relative to the city centre	Total energy kWh/day	Difference relative to the city centre (kWh)
Northern outer suburb	51	2.22	445,558.2	244,620.2
Northern inner suburb	31	1.35	270,829.5	69,891.5
City centre	23	1.00	200,938.0	0.0
Lidingö	32	1.39	279,565.9	78,627.9
Southern inner suburb	33	1.43	288,302.4	87,364.4
Southern outer suburb	48	2.09	419,348.9	218,410.9

It is also relevant to point out that the performance of the project's planning concept is not only the product of environmental goals but is also based chiefly on its strategic location to the city centre. Central to this perspective is the fact that walking and cycling will be promoted for those living, working or visiting the area. The feasibility of these transport modes to increase is highly influenced by the project's location as they would be significantly hampered by longer travel distances.

Land use

It is undeniable that the Stockholm Royal Seaport project brings in a new "urban concept" for Stockholm. The architectural history of the city has shown that a project of such character will create some controversy. The area will have its own character which could be seen as reflecting today's housing demands and contemporary architectural trends. At the local level, the contrast of two architectural styles in Hjorthagen will be evident; the old functionalist style in the old parts which emphasised the optimisation of floor space in residential design, versus a vision of ample floor space as well as the differentiated and higher building facades that are pervasive in contemporary architecture.

The preservation of the old gasworks in Hjorthagen is also challenging because these infrastructures are culturally protected while needing to be retrofitted in order to comply not only with new uses, but also with new energy standards. This may imply that new materials and building solutions need to be custom-made to fit these buildings without altering their cultural attributes.

Energy

Buildings

It is clear that the expected performance of the new developments in Hjorthagen will be impressive. The implementation of new technologies implies however some degree of uncertainty, not only due to their reliability over the long term, but more importantly due their

acceptance among users. New technological solutions shall therefore be simple and preferably perform better than traditional technologies from a functional point of view. Nevertheless, their design has to be appealing to the user.

Previous experiences have shown that matching what is technically possible, in terms of energy consumption in households, does not necessarily mean that the expected levels can be achieved in practice, as occurred in the case of Hammarby Sjöstad. Energy consumption is very dependent on the attitudes and lifestyles of residents. A change towards the more rational use of energy will probably be difficult and will require a series of incentives comprising both increased accessibility and the continuing affordability of technological solutions as well as tailored information campaigns and support mechanisms. This challenge is already recognised in the project's environmental programme.

Most interesting here is the new approach to local energy production and resource management. This not only regards the installation of solar energy and geothermal devices, but also biogas production through the utilisation of "residual heat" from CHP and the integration of solid waste and waste water. The use of food grinders in the collection and transportation of food residues could be seen as a simple solution for the residents as no significant behavioural change is required. In the long run however, this solution is challenging since new conditions may demand further investments on infrastructure for wastewater management in the city as food grinders become the norm in households.

Transport

Further reduction on car use by both residents and visitors may be difficult given the expected high income levels of a large proportion of new residents in the area. This implies that the impact of fees and charges on parking and car ownership and use could have a limited influence on residents to adapt towards a car-free lifestyle. Therefore, emphasis on informative measures will play a fundamental role in the attainment of the project's goals.

The uniqueness of the policies applied in the Stockholm Royal Seaport project for the transport sector could imply conflicts with visitors as they may not be aware of the conditions for private car transport in the area. Therefore it is important to find ways to ensure awareness of the availability of parking places, fees and rules. Nevertheless, surrounding areas could face the risk of congestion due to an increased demand for parking. This reflection may suggest that measures applied in the Stockholm Royal Seaport development should be adapted beyond the district's boundaries, according to the situation prevailing in neighbouring areas.

The finalisation of Norra Länken will certainly prevent road congestion. Nevertheless, the risk of congestion remains on streets that connect the intervention area to the city centre. Therefore, the success of the measures put forward by the Stockholm Royal Seaport development in the transport sector depends on measures that prevent car use to the city centre.

Water

As noted previously, accessibility to fresh water in Stockholm does not represent a serious limitation to the construction of the Stockholm Royal Seaport development in Hjorthagen. Instead new concepts for wastewater management may be considered as challenging. The fact that water treatment is very energy demanding as well as the fact that organic waste can be collected for the production of biogas and nutrients for agriculture each suggest that different solutions are possible. While the option of using the current wastewater network to transport food waste to Henriksdal's treatment plant seems to be a simple one, it may in the long term imply a significant increase in process energy and thus in the need to enlarge the capacity of both the collection network and treatment plants as this option becomes the norm for across city. The option of local treatment or storage could be more resource efficient but at the same time could face conflicts of interest with local residents, as this type of activity could be perceived as undesirable. Also the fact that the outer parts of the Stockholm region are sparsely populated, at least relative to the rest of Europe, it

may be difficult to justify placing new treatment or biogas plants within densely populated areas in the city.

Newcastle Great Park

The Newcastle Great Park (NGP) project was selected for two key reasons. First, it is the largest planned or ongoing mixed-use development project in the Tyne and Wear urban area. Second, it is interesting to consider the rationale and impacts of the development that are taking place on a green field location rather than one of several available brownfield sites in the city.

The project continues to take shape as a phase by phase development where its origins are based on prospective demand for a combination of detached and semi-detached ‘executive-style’ homes, and new business space located within a ‘self-sufficient’ community concept. Information on the background and current status of the project is found in Newcastle’s Local development Framework Core Strategy from 2008 and the Revised Master Plan from 2006.

Construction began in early 2002 and was scheduled to be completed in 2012. However, due in part to the recent economic crisis, the city and developers have reached an agreement to extend the development timetable by an additional ten years (Firth, personal communication, 2010).

The Planning Proposal

According to Newcastle’s 1998 Urban Development Plan, the NGP has been designed to assist the city in stemming out-migration from Newcastle to the surrounding municipalities (due to a lack of suitable housing). According to statistics described by Peter Jordan, the Regional Projects Director for *Persimmon Homes* (one of the two main developers of NGP), particular concern surrounds resident preferences for larger, more spacious dwellings (personal communication, 2010). He notes that roughly 83% of the inhabitants already living in the NGP fit into this target market – residents who would have otherwise taken their investment and tax base either

outside the municipality or the region. Thus, the goal of the NGP is to provide a building stock that increases the attractiveness of Newcastle for investment, both in terms of the business and residential tax bases.

Newcastle has a large supply of housing stock that is in high demand – which is reflected by high prices – but these areas are contrasted by inner areas that have shown market weakness and even market failure (Newcastle City Council, 2008). These areas have been the focus of a housing market renewal scheme (The Bridging Newcastle/Gateshead Pathfinder), which focuses on a comprehensive approach to the regeneration of stigmatised areas close to the inner city (Newcastle City Council, 2008).

In light of the renewal scheme, the Revised Master Plan (Newcastle City Council, 2006) states that specific measures are needed to ensure that the development of the NGP does not jeopardise the goals of inner city renewal. This includes: the mandate that NGP developers also work to identify and develop brownfield sites earmarked as renewal areas; and that the development rate in NGP not exceed 250 homes per year. These are both precautionary measures to safeguard prospective investment needs for inner city renewal programmes in Newcastle (MacDonald, 2006). Thus, there is a clear attempt to strike a balance between the development of housing to stem population loss, while not developing too much of a particular housing type which could potentially accelerate the out migration of residents from vulnerable inner-city urban areas (MacDonald, 2006).

The Revised Master Plan states that the NGP will offer approximately 2,500 residential dwellings for roughly 6,000 people. In an effort to create a diverse, mixed-use area 80 hectares has been designated for employment; thereby providing space for between 6,000 and 10,000 jobs. This is in addition to the distribution of commercial space and other social, cultural and recreation facilities that will provide local jobs to sustain the resident population. These facilities include a community centre, a building for religious activities, a library, a private hospital, indoor

sports hall, day-care and a school (Newcastle City Council, 2006).

However, development of the project has not taken place as quickly as originally planned. Construction was never officially halted during the economic crisis, but like many development projects in the U.K., it slowed to the point where homes were built on the basis of individual orders rather than on speculation (Firth, personal communication, 2010). While speculative housing has restarted, the outcome is that only two of the development cells are complete while, two are under construction, while a further two have yet to break ground and remain without detailed development plans. The development of local businesses has been even slower. While two business parks have been built, there is still plenty of space for further development in both cells, along with a third cell designated for non-residential development. Construction of these cells is on a 'build to order' basis and economic development is losing out to other areas of the city that are seen as more desirable for business investment (Firth, personal communication, 2010).

According to the development trajectory, the intervention area is limited to the extent of the NGP that is either completed or is currently under development. This means that the completed areas of business and industry in Cells B and C, Cell H – which will contain the main commercial centre, the East Village and two areas of housing – and the residential developments in Cells G, H and I are viewed as the intervention area (Map 4). This study cannot accommodate cells A, D, and E, because detailed plans have not yet been prepared and fundamental questions remain over how the development will proceed in these areas. For example, according to Mick Firth, the Lead Officer of the NGP development, business and industry development will not proceed in Cell A without the necessary demand and there is potential that it will be developed as an additional residential quarter (personal communication, 2010). Similarly, there is an ongoing discussion over the type of housing that should be constructed in Cell D. This could have important implications on the future residential density of the quarter.

Based on the definition of the intervention area, the development cells cover an area of 122.8 hectares, entail 1,846 homes for approximately 4,430 residents, and will provide approximately 2,500-3,000 jobs. However, the areas surrounding the development cells are included in the planning proposal as strategic green space, which mean the intervention area⁴ totals 278 hectares.



Map 4. The Newcastle Great Park intervention area and individual development parcels (Image source: Google, 2010; Data: Newcastle City Council, 2006)

Map 4 shows the development parcels within the NGP. It is important to point out that while the total area of the NGP development covers 4,034,894m² (the area outlined in red in Map 4) this assessment is only based on those areas where detailed land use and building plans have been formulated. Accordingly, cells A, D and E are not included in this assessment due to a lack of detailed information.

Newcastle City Council reports that sustainability issues take “centre stage” within the overall development agenda. These approaches are expressed within the master plan and sustainability appraisal for the NGP, and include issues relating to

⁴ The terms “intervention area” and “planning proposal area (PPA)” are interchangeable, while the NGP refers to a more general conception of the project.

social, economic and ecological stewardship (Newcastle City Council, 2006; MacDonald, 2006). From a resource-oriented perspective, some of the main components of the development include:

1 Land use

- To create “complete communities” that offer residential, employment and public service opportunities within a local area. This offers social and environmental benefits by simplifying people’s everyday lives and promoting non-car transport options.
- Offering a mix of housing types.
- Development principles that maximise nature conservation by protecting and enhancing designated wildlife networks (corridors). Development principles also emphasise the integration of the built and un-built environment in ways that promote the mutual respect and utility of nature.

2 Energy

2.1 Buildings

- No mandates within the planning proposal go beyond the energy efficiency standards implied by the building regulations that govern development in the UK. The Revised Master Plan (Newcastle City Council, 2006) states that developers should make “reasonable endeavours” to promote energy efficiency in all buildings, but Council leaves the responsibility to them for increasing levels of insulation, boiler efficiency and the use of solar thermal heating beyond standard guidelines.
- “Energy projects” are publicised by developers and available for public viewing to illustrate new technologies designed to improve energy efficiency.

2.2 Transport

- A network of cycling and recreation routes for walkers, cyclists and horse-riders.
- Developers and City Council liaising with local businesses to implement “Green Travel Plans” and other demand management techniques that focus on those commuting into the development area for work.

- A park and ride facility with 800 car spaces for those travelling into or toward the city centre.
- Increased bus service to, from and throughout the development area with the goal of keeping a 400m maximum distance between all residential units and bus services.

3 Water

- The U.K. government requires that new dwellings must have technologies incorporated to limit the consumption of potable water to 125 litres/person/day (Communities and Local Government, 2009).
- The NGP will have a dual drainage system where the collection and management of surface waters is separate from the collection, transfer and treatment of waste water. This is viewed as a key factor allowing development at the NGP to continue without the need for additional sewage infrastructure.
- The NGP development consortium has worked to implement a storm water management strategy based on the principle of sustainable drainage systems (SUDS). The installation of ponds, wetlands, dry holding and a strategic green corridor form integral parts of the strategic green space that simultaneously create pleasant ‘natural’ environments, wildlife habitats and a means of containing and treating storm water *in situ*.

The Intervention Area

The NGP is being developed in the administrative unit of Castle Park, which has a population of approximately 9,900, making it the fourth largest ward in the city. Castle Park is located approximately 7 kilometres north-west of Newcastle city centre and 4.5 kilometres from Newcastle International Airport. The area being developed was previously agricultural with no pre-existing residential or commercial buildings, or road network. It is accessible from the city centre by the A1 corridor, a main arterial route in the North East Region. While there is an existing bus route serving the area around the NGP it is important to note that there is no Metro connection. Furthermore, Metro expansion is not a part of the

Table 3. Land cover / land use types and estimated sealed surface coverage for the study area

	N ^o Units (blocks)	Area (m ²)	Area (ha)	% of Area	Sealed Surfaces %	Sealed Surfaces (m ²)	Sealed Surfaces (ha)
Commercial / Office (potentially mixed use)	7,980	18,210,620	1,821.06	16.05%	85%	15,479,027	1,821.06
Industrial	98	508,419	50.84	0.45%	100%	508,419	50.84
Public Services	1,017	3,928,331	392.83	3.46%	65%	2,553,415	392.83
Single Family Homes	2,101	1,233,401	123.34	1.09%	60%	740,041	74.00
Medium Density Residential	101,220	25,603,441	2,560.34	22.57%	80%	20,482,753	2,048.28
High Density Residential	19,557	17,628,217	1,762.82	15.54%	85%	14,983,984	1,498.40
Transport Areas	144	326,070	32.61	0.29%	100%	326,070	32.61
Property Shells	1,605	5,790,208	579.02	5.10%	60%	3,474,125	347.41
Leisure or open space (green space)	893	20,425,173	2,042.52	18.01%	0%	0	0
Unclassified	169	19,781,428	1,978.14	17.44%	10%	1,978,143	197.81
Total	134,784	113,435,308	11,343.53	100%	53.36%	60,525,977	6,052.60

development, nor is expansion to the area a part of the regions' long-term transport strategy. The population is characterised as being dominated by two-parent families and young people, with a low proportion of single-parent families (MacDonald, 2006).

The study area (The city of Newcastle)

At present, planning in Newcastle is in a dynamic state. This is due to a number of factors, including the recent structural amendments to land use planning in the U.K. Noteworthy changes were made in 2004 and again in 2010 - the latter of which abolished "regional plans" in England, thereby leaving a gap in the strategic planning framework. In addition, Newcastle City Council had moved towards producing a new Core Strategy in 2008, but was forced to withdraw it when Central Government concluded it had been based on insufficient evidence. It is therefore necessary to view the policies laid down in the draft plan as being an indication of the desired approach, while acknowledging that they may be subject to change.

The Draft Core Strategy stated "The existing urban areas will remain the focus for development activity and new development will be concentrated as far as possible towards the centre of the city" (Newcastle City Council, 2008, pp. 14). In this regard, the aforementioned planning principles of city centre redevelopment and housing market

renewal characterise the political discourse of land use development in Newcastle.

Land use

While the heart of the inner city is a vibrant commercial zone, animated by student life and a strong amenity-based economy, many parts of the inner city have been hollowed out by the decline of industry and by suburbanisation (1NG, 2010). This is very much in line with economic transition that has taken place in the region in the past half-century. In particular the area along the River Tyne in central Newcastle was generally used for heavy industry and manufacturing, as well as for basic housing for workers in these industries. While economic production in Newcastle has shifted towards knowledge-intensive sectors, the physical remnants and social stigma of former land uses persist. Accordingly, processes of suburbanisation to peripheral areas in the Tyne and Wear urban region are characteristic of spatial development in the region.

While information within the Core Strategy and Area Action Plan's provides a general picture of land use and development in Newcastle, identification of specific land use is based on raw data contained in the 2008 release of Newcastle City Council's Property Gazetteer. The Gazetteer accounts for approximately 85% of the 113.4 km² area in Newcastle. In Table 3 below, the remaining 19.8 km² is unclassified. In reality, these areas are typified as

un-built areas sharing similarities with the “Open Land” Classification provided by Table 3.

The BLPU classification scheme distinguishes eight primary land use classifications: Commercial, Land, Military, Parent Shell, Residential, Unclassified, Mixed and Objects of Interest. Within these categories, the classifications are further broken down into 32 sub-categories and 111 tertiary categories. Based on the BLPU categories, 11 land use categories have been identified and compiled to provide consistency between each of the MIA case studies. The sum of the areas covered by each is shown in Table 3.

The land cover figures in Table 3 indicate that 39% of the land is covered by residential properties, with “Medium Density Residential” covering the largest area of any land use type. “Open Land” and “Unclassified” accounts for over 31% of the land in Newcastle. Based on the estimated percentage of sealed surfaces for each land use type, it is approximated that 53.36% of the area in Newcastle is sealed by artificial surfaces.

Energy

Figure 11 provides a general illustration of the energy mix in Newcastle, both in terms of the type of energy consumed and its distribution per sector, as well as the inputs and outputs of its energy flows. As such, there are a number of characterisations that can be made from the data provided in Figure 11.

In 2006 Newcastle consumed 6.82TWh of energy in a mix of forms. Figure 12 below shows that the supply of energy is predominantly served through

the consumption of natural gas, which accounted for 49.7% of supply in that year. Following natural gas, 29% of total energy use was met through the combustion of petroleum products, of which 86.5% was used to power vehicles in the transportation sector. Electricity was the only other key energy source, meeting 21% of total energy demand. As seen in Figure 12 this mainly served the industrial sector, with a notable share also serving domestic demand.

Newcastle’s dependence on natural gas is also very clear as indeed is illustrated in Figure 11; particularly in the domestic and industrial sectors. From a national perspective, while the UK is one of the world’s largest producers of natural gas (the United States Energy Information Administration reports that there are 10.3 trillion cubic metres of it available domestically) their known reserves have been reduced by 15% in the past year. Furthermore, production rates have been declining steadily since the mid-1990’s, and in 2004, the UK became a net-importer of natural gas. (USEIA, 2010)

buildings

Figure 11 quite clearly shows that the domestic sector is reliant on natural gas to meet demand for space and water heating. Consuming 2.07TWh of natural gas in 2006, it is the sector with the highest consumption of an individual energy source. Figure 11 also indicates that 81% of domestic energy demand is used for space and water heating while the remaining 19% is based on electricity demand.

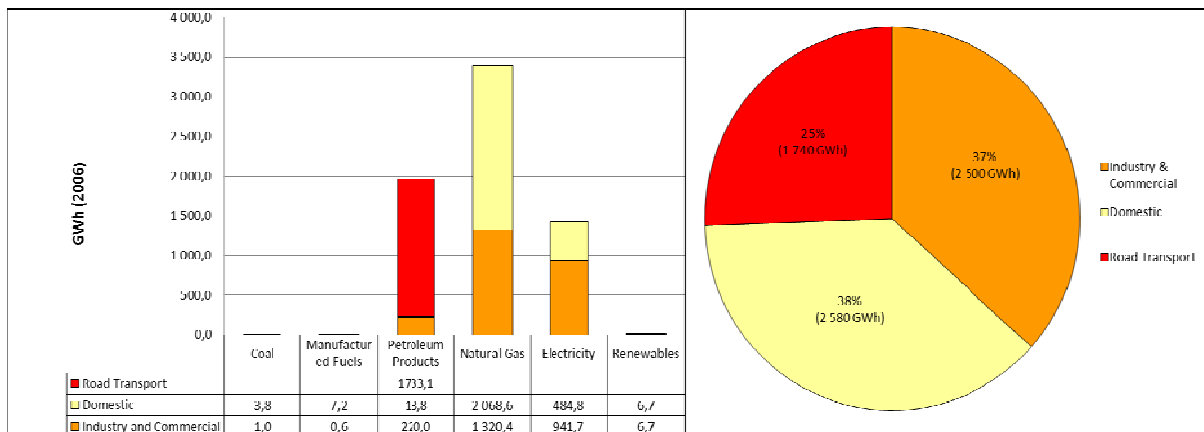


Figure 11. Energy consumption by sources and sectors for Newcastle Upon Tyne (2006) (DECC, 2009)

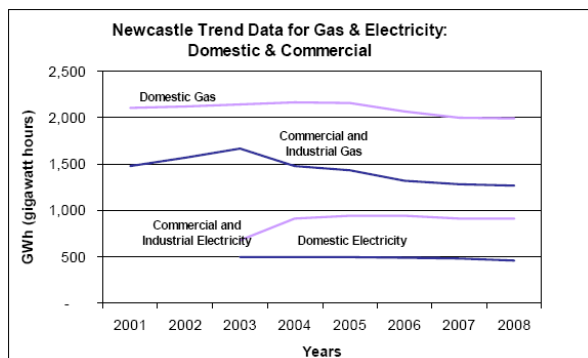
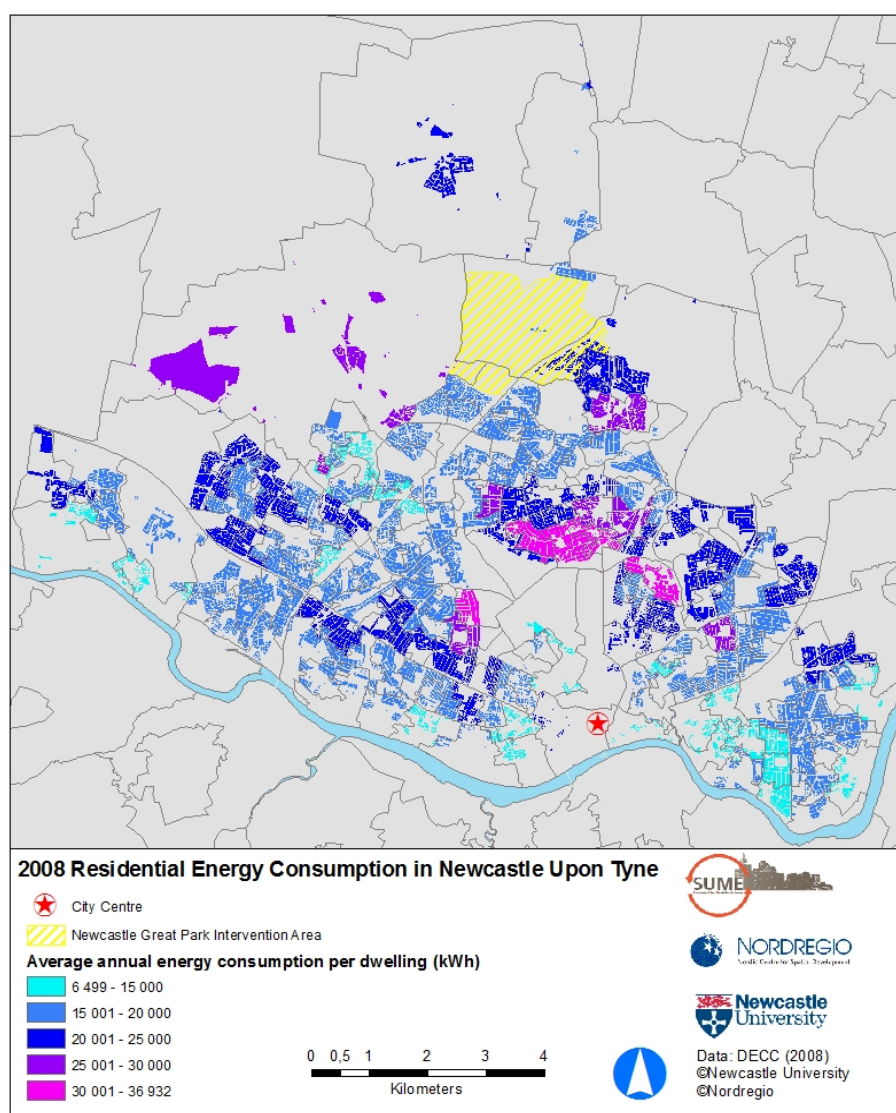


Figure 12. Recent trends of gas and electricity consumption for Newcastle. (Newcastle City Council, 2010)

In addition, Figure 12 shows that there have been reductions in natural gas consumption; but since 2003, savings have been much higher in the commercial and industrial sectors as compared to the domestic sector. Electricity consumption has not fallen to the same degree where, particularly in the domestic sector, electricity consumption is prone to the rebound effect (Newcastle City Council, 2010). Ultimately, it is seen that energy consumption in the domestic sector (electricity and natural gas combined) has increased slightly in Newcastle since 2003.



Map 5. Estimated energy consumption (gas and electricity) of residential buildings in Newcastle Upon Tyne (Data source: DECC, 2008)

Based on the range of average consumption shown in Map 5 on page 31 (between 6.49MWh and 36.93MWh/dwelling/year) there is a wide disparity in energy use across the city. Statistics also indicate that in 2008 average energy consumption was 19.27MWh/dwelling/year across the municipality⁵. Unfortunately there is no detailed data available on the amount of floor space of individual dwellings in Newcastle. Had this information been available, the energy consumption levels (per dwelling) could have been normalised to floor space. However, it is inferred that the wide distribution of residential energy consumption is chiefly related to the correlation between high energy consumption and larger living space (the floor space factor). Ultimately however, there is likely a dynamic interaction between the floor space factor, the socio-economic status of residents and the age of the buildings. The correlation between floor space, socio-economic level and energy consumption is obvious, where larger living spaces cost more money to purchase and they also demand more energy for space heating. Similarly, socio-economic status also implies increased discretionary income for the purchasing additional electrical goods. Building age is also an important factor here because older buildings have proportionately higher energy consumption due to reduced insulation quality.

Map 5 shows that the lowest residential energy consumption levels are concentrated in an area roughly 1.5 km to the east of the city centre. These areas are characterised by relatively poor building quality, small living spaces, and consequently, the reduced socio-economic status of residents. In contrast, roughly 3 km north from the city centre is an area of relatively high energy consumption; however, this neighbourhood is identified as having some of the largest and most expensive dwellings in

Newcastle. This adds credence to the argument that domestic energy consumption is significantly influenced by the size of dwellings and the socio-economic status of the residents living in them. Based on a much higher variations of natural gas consumption compared to electricity demand across the study area (DECC, 2008), it is therefore likely that domestic gas consumption is mostly related to the floor space factor; with building ages and income levels having subsidiary influences.

In more general terms, there appears to be a spatial explanation for the distribution of Newcastle's residential energy consumption. Except for the few dwellings in the city centre, there is a clear area of comparatively low consumption within and surrounding the inner city. Next, there is a ring of housing that accounts for the highest per metre energy consumption in the city. These areas are the inner-most suburban communities that are characterised by high market demand and large living spaces. Within this ring, there is also a patchwork of lower consumption, which is likely related to the fact that some areas have been re-developed with larger, more expensive homes while others still consist of older and smaller dwellings.

Lastly, a ring of cells with high energy consumption appears toward the outskirts of the municipality. These are generally newer dwellings which can be characterised as peripheral suburban communities in Newcastle.

Lastly, Map 5 shows the two eastern development cells in the PPA (H and I) as exemplifying peripheral suburban areas with relatively high energy consumption. It is interesting to note here that development cells H and I represent over half of the dwellings in the LLSOA; and with an average annual consumption rate of 24.6524,645 MWh/dwelling/year, it ranks as the 14th highest LLSOA (out of 173) in terms of average domestic energy consumption.

Transport

Figure 13 illustrates the estimated consumption of transport fuels in Newcastle and shows that 80,500 tonnes of fuel was consumed by private automobiles (petrol and diesel cars) in 2006. Cumulatively, this

⁵ There is an inherent miscalculation in the delineation of domestic and non-domestic consumption statistics on gas and electricity. This is related to the fact that a consumer is considered as domestic or non-domestic based on consumption thresholds rather than actual use of energy. For example, a consumer is considered to be "domestic" if their annual gas consumption is below 73 000 kWh/year and electricity consumption is below 100,000 kWh/year. Therefore, it is inevitable that the "domestic" sector includes some demand that is related to economic activities.

means that roughly 65% of transport fuel

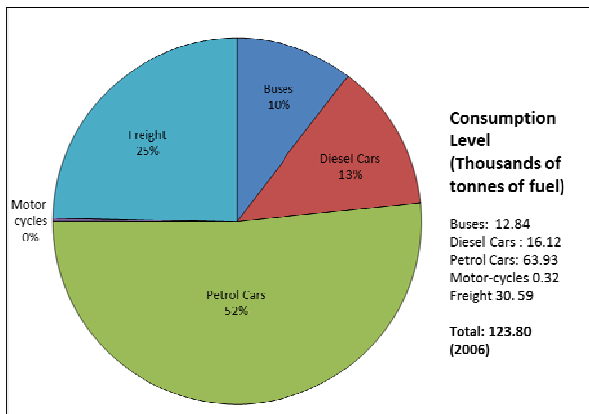


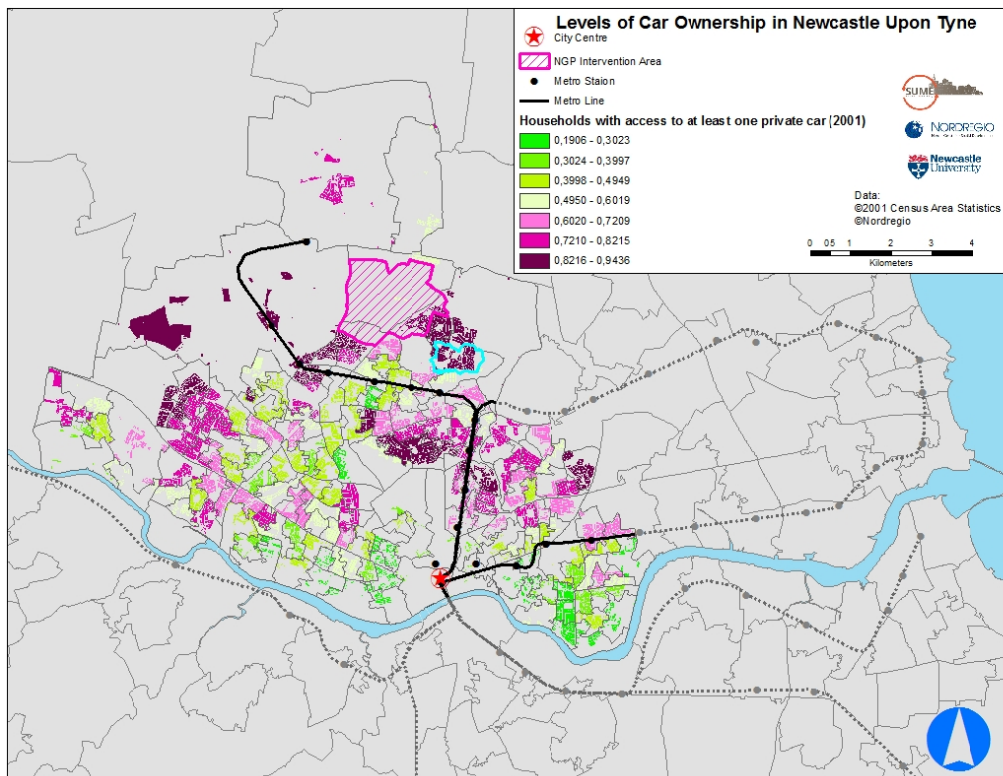
Figure 13. Consumption of energy fuels for road transport
(Data source: DECC, 2010)

consumption is allocated to powering private cars. These statistics are contextualised by the fact that 2001 census data showed that 59% of the employed population in Newcastle used a car to commute to work, compared to only 21% who relied on public transport. As such, the totals in Figure 13 are notable in two respects. On the one hand the absolute values of consumption are quite high considering the size

of the municipality; and, on the other hand, the relative consumption by private cars compared to that of other transport uses is also significant.

Map 6 depicts the distribution of car ownership per household at the LLSOA level in 2001, which represents the most recent census data that is available. The data indicates that 56% of households in Newcastle have access to at least one private car. Statistics also indicate an average of 0.744 cars per house or 0.314 per person in 2001. It is also relevant that in the areas to the east and south of the intervention area, there are up to 1.507 cars per household. Accordingly, there is a clear relationship between low levels of car ownership in areas most proximate to the inner city and higher ownership rates with increasing distance from the city centre.

Less than 30% of homes in areas directly to the east and west of the city centre own a car. Based on the previous discussion, it is assumed that the lower levels of car ownership are due to the interplay between reduced demand for a vehicle and the inability of the residents to afford a private vehicle. These communities are contrasted by peripheral



Map 6. Per household car ownership in Newcastle Upon Tyne (Data source: Census Area Statistics, 2001)

areas in Newcastle, where car ownership averages exceed 82% per household. These areas are characterised as having “patchy” distributions of suburban, low-density housing that do not motivate the development of high level public transit without significant public sector subsidy. This then creates a dependence on private cars in these areas. As such, the causality between proximity to the city centre and car ownership is based on three factors: trip length (to work and to commercial areas for meeting daily needs), residential dwelling density and effectiveness/efficiency of public transportation alternatives.

A second clustering of LLSOA’s to the north of the city centre also has proportionally high car ownership. These cells are noteworthy due to their close proximity to the inner city and the fact that a metro line bisects the clustering. Based on the previous discussion on city centre proximity and access to public transit this neighbourhood should be prone to lower levels of car ownership as public transit appears to be an efficient alternative for the meeting of everyday travel needs. However, as noted during the discussion on residential energy consumption, this area is identified as consisting of the most desirable (expensive) housing in Newcastle. This implies that residents can afford the cost of owning a car regardless of perceived need. As a result, it is also indicative of the persistent behavioural tendency that favours car-dependent, suburban residential living environments.

The recently completed SOLUTIONS (Sustainability of Land Use and Transport in Outer Neighbourhoods) report by the U.K.’s Engineering and Physical Sciences Research Council indicates that travel demand is expected to grow by 6.1% person trips between 2000 and 2031. However, due to the fact that the number of car trips is expected to increase by over 20%, Figure 14 shows that the modal share of car trips should increase by almost 8%. The main reason for the growth in car use (and thus for the reduction in the proportion of trips by public transit or walking and cycling) is that car ownership is predicted to increase from 57% to 73% of households by 2031. As shown in Figure 15, the increase in car trips coupled with a 5% increase in

the average length of each car trip (from 11.2 km to 11.8 km per trip) implies that there will be a 24% increase in the total distance travelled by car. (Rice *et al.*, 2010)

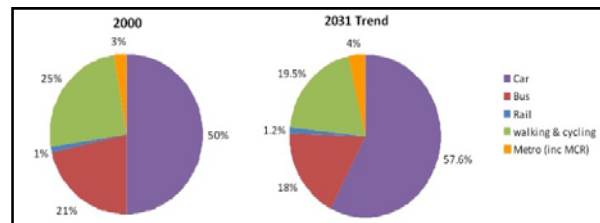


Figure 14. Trend in mode split by number of trips in Tyne and Wear (Rice *et al.*, 2010)

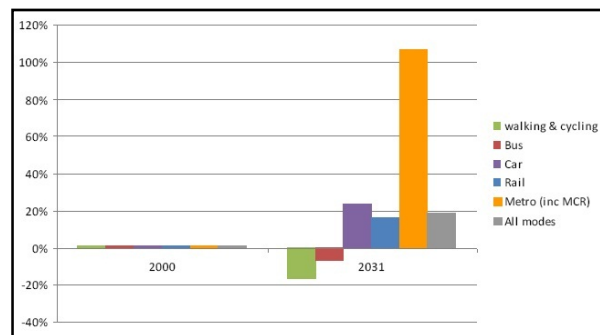


Figure 15. Change in passenger-km by mode up to 2031 (Rice *et al.*, 2010)

Water

The reporting of statistics on water supply, consumption and deposition is hampered by a lack of comprehensive data for Newcastle. The distribution of potable water and wastewater collection, treatment and disposal are conducted by *Northumbrian Water Group* (NWG); a company serving the water and sewerage needs of over 2.6 million residents in the North East Region. Within the region, Newcastle accounts for approximately 34% of NWG’s water transfers (Northumbrian Water, 2010a)⁶.

According to the National Water Service Regulation Authority (Ofwat), average household water consumption in the North East Region has been relatively steady during the past 10 years. Figure 16 shows that average domestic water consumption has varied between 155 and 164 L/cap/day during

⁶ Based on the share of National Insurance Number Registrations in Newcastle compared to the rest of the regions. See page 156 of Northumbrian Water Group, 2010a.

the period 2000 to 2009. Average *per capita* water consumption was 158 L/cap/day in 2008-2009 for the region, which is 10.5% above the current national average. Based on the 158L/capita/day rate of domestic consumption shown in Figure 16 it is estimated that Newcastle consumes 43,892,400L/day, or 16,020,726m³/year for domestic purposes (Ofwat, 2009a).

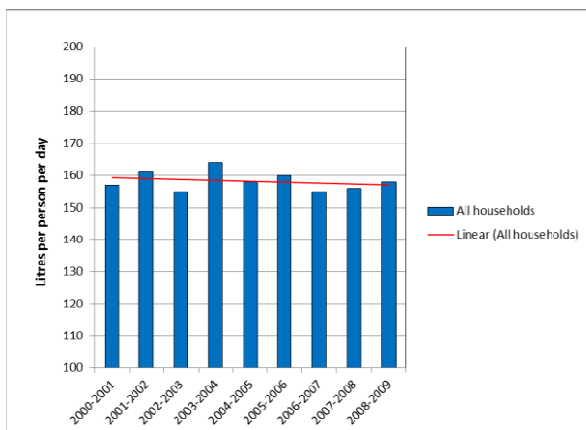


Figure 16. Average household water consumption for North East (2000-2009) (Data source: Ofwat, 2009a)

Water loss caused by leakage in the distribution infrastructure has averaged 146,250m³/day over the last four years (Ofwat, 2009b). In each of these years, the estimated water loss has been under the target levels established by NWG, which suggests the water infrastructure is stable in the region (the marginal cost of active leakage control is currently higher than the marginal cost of water lost through leakage) (Northumbrian Water, 2010a).

Lastly, each resident in Newcastle produces between 135 and 180L/day of sewage which is collected at treatment plants throughout the region; the largest being the Howdon facility near the mouth of the River Tyne (Northumbrian Water, 2010b). In the vast majority of cases sewage and surface storm water is combined within the network of collection infrastructure and treated in line with the EU's Urban Wastewater Treatment Directive. It is then released into the River Tyne where it eventually flows into the North Sea. Also, since 1998 residual sludge from wastewater is no longer discharged into surface waters and is recycled through a variety of secondary functions. These include uses as

agricultural fertilizers or sludge pellets used to supply energy to local industry (Northumbrian Water, 2005).

Evaluation of the impacts

Land Use

Some caution must be exercised when comparing land cover / land use between the study area and intervention area. This is mainly due to the fact that the city-level land use data is based on Newcastle's Property Gazetteer and this data is not available for the planning proposal area. Therefore, land use in the NGP can only be approximated based on various planning documents and interviews with local planners and developers.

The consumption of land in the PPA will amount to 2.74km², or 2.41% of the 113.44km² covered by the study area. This will correspond to a population density of 16.18 residents per hectare compared to 24.46 residents per hectare in the city as a whole.

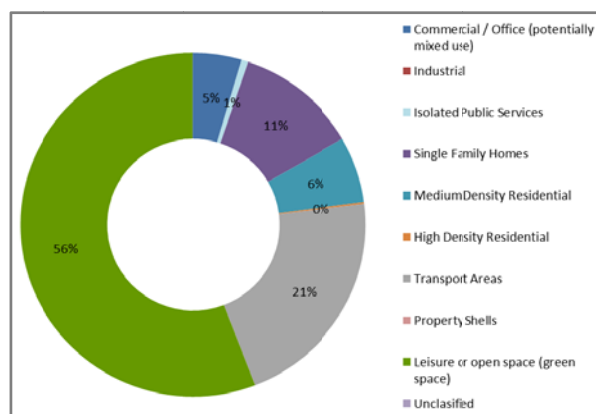


Figure 17. Land uses within the study area

Leisure or open space (green space), and unclassified areas (assumed to be other undeveloped areas) make up 35% of the land in the city, which corresponds to approximately 28.06m²/cap. This is largely due to the aforementioned importance of protected green spaces and green corridors in Newcastle. Green space, however, will cover approximately 56% of the PPA, which in turn corresponds to 318.87m²/cap. While green space that is over 11 times higher *per capita* suggests increased metabolic performance, two points must be considered. First, the PPA is being developed on

a *green field* site, which means that any green space within the plan will maintain its previous land type and is not contributing positively to the protection of land. Second, different property types have varying average proportions of sealed versus unsealed surfaces. For instance, single family homes have a sealed surface percentage of 60%, while medium and high density residential land used have 80% and 85% respectively. With this in mind, analysis of the Newcastle Property Gazetteer indicates that there are 122,878 dwellings in Newcastle; of which 1.7% are detached single family homes, 82.4% are medium density (semi-detached or terraced) and 15.9% are high density apartments. In comparison, 58.2% of the dwellings in the PPA will be detached single family homes, while only 35.1% will be medium density and 6.7% will be in dense, mixed use buildings.

Based on the estimated percentages of sealed surfaces for each land use within the Property Gazetteer, approximately 53.36% of land in the municipality is impermeable, while approximately 37.38% of the PPA will correspond to sealed surfaces. While the 15.98% difference appears to be high, again it is important to consider the amount of green space being preserved in the development, which is factored into the calculation. If leisure space, open land, unclassified areas and green space are omitted from the assessment of sealed surfaces, roughly 80% of the built environment in Newcastle is impervious, compared to 71% in the PPA. The lower level in the PPA is related to the increased

proportion of single family homes (and their lower average sealed surface percentage) relative to the rest of the city.

The estimated total land consumption *per capita* for the study area amounts to 408.33m²/cap in 2008. In terms of mainly sealed surfaces (excluding leisure or open space, and unclassified land) this amounts to 263.60m²/cap. When we calculate the same parameter for the PPA we find an expected land consumption of 617.96m²/capita for the 4,430 estimated residents. This 51.34% increase in land indicates reduced land efficiency for NGP. In terms of mainly sealed surfaces (excluding leisure or open space) it amounts to a reduced efficiency of 13.46% in NGP. This indicates that NGP entails an inefficient land consumption that accentuates the entrenched issues of low density, peripheral and car-based development in Newcastle.

Lastly, while the NGP plan was promoted as providing a mix of residential, occupational and public service uses in close proximity, the land use mix index is estimated at between 32% and 37% lower than the average in the municipality. This will become even lower if Cell A is transformed from land designated for economic development into a low density residential “pod”.

Energy

Buildings

Average residential consumption is calculated by multiplying the average floor space of the 1,846 dwellings to be constructed in NGP by the average energy consumption (per square metre) for 100 of the completed dwellings in NGP (as provided by their Energy Performance Certificates). The 2008 domestic energy consumption statistics indicate that residential buildings in Newcastle consumed approximately 2.37TWh of energy (1.91TWh in natural gas and 0.45TWh in electricity), which amounts to an average of 19.27MWh/dwelling/year and 8.53 MWh/cap/year (23.4 kWh/cap/day). Current development indicates that NGP will have annual domestic energy demands of 31.44GWh per year (25.51GWh of energy in gas for space and water heating, and 5.93GWh of electricity for lighting and

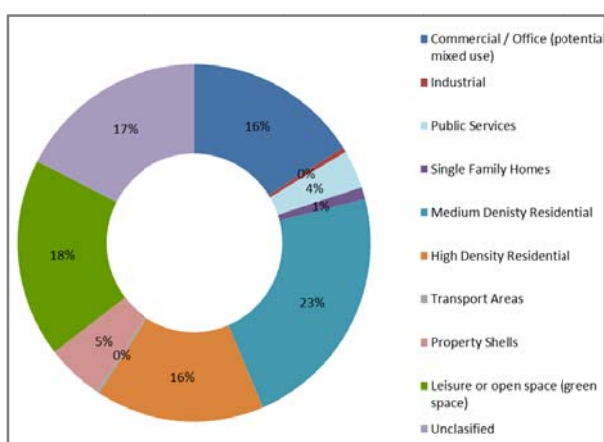


Figure 18. Estimated land uses within the planning proposal

appliances). Based on an estimated population of 4,430 inhabitants this corresponds to an average of 19.44 kWh/cap/day.

In relation to the rest of the city, dwellings in NGP will reduce per dwelling energy consumption by an estimated 11.6%. Likewise, while domestic consumption is estimated at 23.4 kWh/cap/day in the study area, it will be roughly 19.44 kWh/cap/day in the PPA – a 16.9% improvement. While these statistics indicate a slight improvement over the existing building stock in the city, three points weighing against a perceived improvement need to be considered.

First, there is a significant difference between ‘current’ and ‘potential’ levels of electricity consumption for all homes with an environmental performance certificate in the PPA. This implies that low-cost electricity saving measures are not being used to their full potential. Second, as described above, SAP guidelines are used to calculate the energy efficiency of all future developments in NGP and there is no mandate to implement building efficiency standards beyond those which are legally binding within the UK building code (Ewles, personal communication, 2011). This is important because it means that the average 25% increase in energy efficiency gained by the revamped SAP 2009 is not being used to help guide construction of the remaining buildings in the PPA.

Third, while the houses in NGP are built according to U.K. building regulations on energy efficiency, the 11.6% estimated improvement in average annual energy consumption per dwelling is simply not substantial. Even though homes in NGP will be much larger than the average across the city, it is well known that the development of new technologies for homes (economy 7 metering⁷, real time energy monitoring, low energy lighting and appliances, passive energy construction, *in situ* renewable energy production, etc.) have been developing at a high pace across Europe. These technologies have rationalised previous policy

⁷ Economy 7 metering refers to a differential tariff that motivates consumers to use energy during night time hours when energy demand is generally not as high. The night period lasts for seven hours, hence the name Economy 7.

discourse in the U.K that suggested all new homes will be emission free by 2015 (HM Treasury, 2006).

Transport

The development of NGP will negatively influence transport fuel consumption due to the peripheral location of the development, the lack of Metro service and the amount of private parking space provided in the residential development areas.

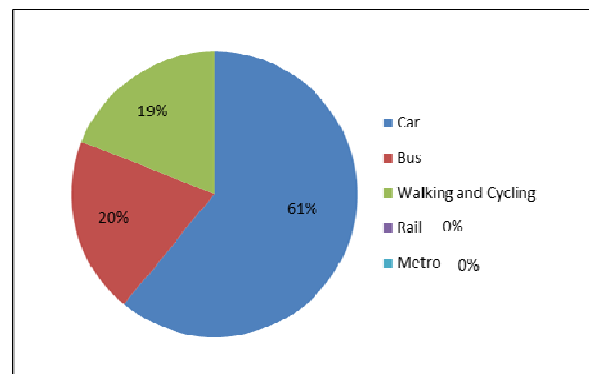


Figure 19. Forecast modal split for NGP, 2031

As illustrated in Figure 19, the private car is expected to be the most prevalent form of transportation in the intervention area. While the average level of car ownership was 0.744 cars per house in 2001 this was elevated to as high as 1.51 per dwelling in areas surrounding the PPA. Accordingly, this highlights the correlation between peripheral areas of the municipality and high levels of car ownership. In the Tyne and Wear region as a whole, the level of car ownership is expected to rise from 0.57 to 0.73 between 2000 and 2031 while the number of car trips is expected to increase by 20% (Rice *et al.*, 2010). Thus, (normally two spaces per dwelling), indicates that car ownership in the PPA will be at least equal to the surrounding areas. The peripheral location also reinforces the trend of increasing average trip lengths in Newcastle.

Based on the presence of 1,846 homes, it is estimated that there will be at least 2,671 private cars in operation by residents in the PPA. Additionally, it is estimated that there will be at least 3,027 non-residential parking spaces. This implies a total of 5,788 spaces for cars in the PPA. The a Local Trip Generation and Distribution Model for Partnership Working on the A1 Corridor within Newcastle

estimates that there will be approximately 9,281 in and out of the completed intervention area during peak hours. The forecasted growth of average trip lengths in the Tyne and Wear metropolitan area to 11.8km in 2031 (Echenique *et al.*, 2010 p. 140) and by comparing this to average fuel consumption, which for new vehicles in England is 0.0747 L/km, we can infer that peak hour trips to and from NGP will consume approximately 8,180 litres of gasoline (<http://fueleconomy.co.uk>). This equates to 73.62MWh during peak hours per weekday.⁸

Based on calculations made in the trip generation model it is striking that increases in morning out-trips from the development will range from 400% to 1,200% depending on the direction out of the North Brunton Interchange, while even greater relative increases are expected for in-trips during the peak evening hours. While these values are only relative (for example, the 4,600% increase corresponds to 46 new trips going through the North Brunton Interchange and into NGP when none were present prior to development) the high increase directly surrounding the development suggests that current infrastructure will have to be improved to meet future transport demand. While there is no evidence base on potential improvements to the road network surrounding NGP, the fact that the UK Highways Agency has contracted *JMP Consultants* to carry out this modelling is indicative of a realisation that the level of infrastructure along the A1 corridor will have to be augmented.

Water

According to estimates for the PPA, domestic water consumption will be 202,137m³/year (4,430 inhabitants consuming 0.125m³/day). Given that current domestic demand is nearly 0.158m³/cap/day in the North East region, this implies that the PPA will consume approximately 20.8% less water for domestic purposes than the study area. However, it is cautioned that the target consumption rate of 0.125m³/day is only used to guide the installation of efficiency technologies within new dwellings. The vast majority of potential water savings ultimately

comes down to individual consumers that make cognisant decisions to change their consumption behaviours. Therefore, the PPA appears to have no specific impact in terms of water consumption because building standards are based on the national targets that guide construction.

There is no mention here of expected reductions in foul water production in NGP. Regional estimates suggest that residents in Newcastle produced every day between 135 and 180 litres of foul water *per capita* in 2008. Without access to more valid data it can only be estimated that sewage production in NGP will be close to the demand for potable water provided above. At the same time, there is concern that the residential building typology in the PPA – the predominance of single family homes with large private gardens – will negatively affect domestic water consumption, but it is not possible to quantify these potential impacts.

However, the management plan for surface storm water in the NGP will significantly minimise stress on the local wastewater infrastructure as discharge will be limited to the sewage produced by the local dwellings and other buildings. The additional flows should result in less than a 38L/second increase in sewer flows, which amounts to a 1.5% increase in the flow rate along the Ouseburn trunk line during storm conditions, which *Northumbrian Water Group* states is manageable by the current infrastructure. Therefore, the project will contribute positively by adding to the municipal building stock while implementing measures to manage storm water flows locally.

Alternative scenarios and further implications

Alternative areas

The analysis of two alternative development locations benefits significantly from the SOLUTIONS report. It includes a local case study for the Tyne and Wear metropolitan area that, in light of the need for additions to the local housing stock, assesses different locations for development and determines the impacts of multiple development options and scales for influencing sustainability.

⁸ Karlsson I. and Johansson A. (2009) Beräkningsmodell för bensin respektive diesel förbrukning per kommun. Statistics Sweden.

The SOLUTIONS assessment motivates an evaluation of alternative scenarios and their impact on the metabolic performance in the intervention area for a number of reasons. Most importantly, NGP is being constructed on a green field site despite the fact that brownfield areas are available for development towards the city centre. Also, within Newcastle's planning discourse, there is a clear discussion of the need to avoid the continued growth of suburban mono-functional areas and to reinvigorate the inner city with a dense, mixed use, and sustainable urban form. Yet the NGP project has the opposite effect. This highlights the challenges that hinder the ability of planners and policy makers in Newcastle to implement their policy visions. First, alongside the growth of knowledge intensive jobs there are an increasing numbers of high income workers in Newcastle who seek suburban living situations with executive-style homes, private green space and private car accessibility. Without the resources to initiate comprehensive policy tools to increase consumer demand toward higher density urban living, the city council is compelled to provide this housing supply to avoid losing residents (and their tax base) to neighbouring municipalities. Second, and related, there appears to be relatively little cooperation between the six municipalities that make of the Tyne and Wear urban region. The result is a development of housing stock in Tyne and Wear that operates in zero-sum terms; where if Newcastle does not respond to market demand, consumers will take their business to other municipalities.

Great West Park

The Great Park West alternative highlights the availability of land along the existing metro line running from Kingston Park (at roughly 1.5 km south of NGP, the closest station to the development) to the airport. The area consists of three existing metro stations; none of which are heavily developed or have specific conditions prohibiting development and an existing thoroughfare. (Rice *et al.*, 2010)

- A qualitative assessment of Great Park West was undertaken in the SOLUTIONS case study, in

which different urban form scenarios were appraised. Compared to NGP, the alternative of basing development along the existing metro line was seen as reducing car dependency and stakeholders generally felt that if the decision on developing NGP was taken today, the Great Park West site would have been chosen over that of NGP (Rice *et al.*, 2010). It appears as if two key factors guide this rationale. First, planning for NGP began in the late 1990's when the issue of sustainability was not as important as it is today. Second, within the current economic climate it remains difficult to envision the levels of investment that would be necessary to extend the current public transit network in Newcastle.

- One of the benefits of the Great Park West option is that development could be incorporated into existing settlements. While some stakeholders commented that there could be a conflict with some of the existing residents over the proximity of the new housing development, the reality is that such a development would provide additional commercial and public service locations within close proximity. This could impact the transport patterns of those in the existing neighbourhoods; thereby representing spillover benefits that further enhance the sustainability outcomes of development. In addition, the prospective benefits of Gate Park West include:
 - A denser urban form in Great Park West that could provide living space for 14,200 residents. This amounts to approximately 58.67cap/ha, or a 263% improvement over the PPA (16.18cap/ha).
 - NGP will only provide 45% of the residents with at best "poor" access to public transit. In Great Park West 58% of residents would have "good" accessibility to the metro, while 83% would have at least "mediocre" access⁹.
 - The 38% accessibility improvement would be further marked by the fact that NGP will only

⁹ According to the SOLUTIONS project (2010, pp. 8), "excellent" accessibility is defined as the percentage of residents within 600m of more than 11 services per hour, while "good" and "mediocre" relate to a 600m proximity to 5-11 and 2-4 services per hour respectively.

have a bus service compared to the more efficient metro alternative in Great Park West.

- Within 600m of Metro stations in Newcastle there is, on average, 0.78 cars per household. Compared to the 1.5 cars per household average for NGP, this implies a 52% reduction in the number of cars given that all residences in Great Park West would be proximate to high level public transit.
- The increased densities, mixed local land use functions and integration with existing communities in Great Park West would also reduce car demand, and therefore fuel consumption.

Further implications

The ability to attain these development visions promoted by Great Park West would require a number of transformations; each requiring a dedicated, comprehensive, long term and, not least, expensive planning approach. Most significantly, this includes the ability to implement a plan that lays out concise action plans for key sustainability provisions from the outset. Similarly, the ability to undertake much more significant urban and infrastructure restructuring to integrate new development within the existing urban environment, and to commit the resources needed to transform consumer behaviours toward a realisation of the benefits of higher density urban living are also required.

Unfortunately, the reality is that planners in Newcastle do not have the public resources they need to attempt these transformations. They are caught in a paradox where it is recognised that the type of development being pursued in NGP is not contributing toward a more sustainable city, but they are unable to adapt. Thus, it is evident that market feasibility continues to be the primary driver rationalising the location of the development while environmental sustainability is given very little consideration beyond minimum regulatory standards.

Land Use

Although the NGP development has considerable green space it nevertheless remains being

constructed on a green field site. Accordingly, building on one of several existing brownfield sites in Newcastle would make the development much more efficient. It would help to renew existing green spaces or reuse space that otherwise remains stagnant. Further, had such a brownfield site been located in an area with good access to employment, and/or commercial centres or public transit, the total energy consumed for transport would be reduced, thereby making the development more sustainable.

Perhaps most importantly, development in NGP is characterised by low density housing. A denser urban form would reduce land consumption while still providing similar levels of floor space. It would also help facilitate mixed uses to potentially reduce residents' daily travel distances by significant levels. Mixed use areas are also widely understood to be more 'walkable' and 'bikeable', thereby providing residents with an incentive to leave their cars at home. They are also considered to be socially sustainable, and could help to foster a sense of community in the new development.

More efficient land use could also be promoted through a more integrated development structure. Rather than developing independent pods that take more land and require residents to travel greater distances, a more cohesive urban fabric would promote efficiencies and provide a more sustainable alternative. Related to this, greater integration into surrounding communities would increase the likelihood that the development could help to meet the needs of those living in proximity to the project. Integration would also reduce the possibility of wasting space. Rather, like the piece of a puzzle, the development could be placed in an existing hole in Newcastle's urban fabric.

Energy

Buildings

The NGP planning proposal only makes general recommendations on how to improve efficiency rather than specific details regarding energy efficiency improvements for the building envelope. This is a result of the overriding emphasis on economic factors in the development. As one

developer noted, there is little interest in investing in green building techniques because the costs associated with such upgrades do not meet market conditions (Jordan, personal communication, 2010). As such, buildings in NGP are being built to meet the standard building code and there is nothing to suggest that the project will increase the efficiency standards of the remaining homes to be developed, despite the fact that more advanced technologies do exist. At the same time, there are a number of steps that could have been taken to reduce energy use without significant cost. Put together, these measures could significantly reduce energy consumption while simultaneously helping in the transition to a more energy aware populace. For example:

- Solar water heaters could have been much more widely used to reduce dependence on external sources of energy. Currently, only 17 out of 175 homes in Cell H use solar water heaters, but if they were installed on all 1,846 homes, external gas demand would be reduced by 6.46Gwh (20.6% of total energy demand).
- Energy efficient lighting could be installed in all new housing units in NGP. The Energy Performance Certificates indicate that new homes in NGP meet their energy efficiency potential in terms of natural gas demand, but electricity consumption is not optimised because of the lack of energy efficient lighting directly after completion.
- The energy efficiency of the homes in NGP is based on the 2006 Standard Assessment Procedure (SAP) despite the fact that this was updated in 2009. By 'grandfathering' the 2006 code, recently constructed and future buildings in NGP are not required to meet the new standards, which would provide 25% energy savings (SAP, 2009).
- It is understood that a critical element in reducing residential energy consumption relates to the consumption behaviour of residents rather than to technical improvements in building construction. Yet, improving energy awareness among homeowners could have been realised in NGP through a number of low cost initiatives could have included: providing residents with

information on how they can save energy and installing real time "smart" and "Economy 7" energy meters in all homes to show residents how much energy they are consuming, the manner in which it is consumed and to provide them with an incentive to reduce energy consumption during the day.

Transport

The plan for NGP leaves considerable room for improvements in accessibility. Due to the pod-like development design that significantly impedes non-motorised transport, the peripheral location of the development in Newcastle and the lack of suitable public transport alternatives the local transport model is oriented towards the private car. In this case, situating the development in proximity to public transit (such as the Great West Park alternative), and creating a more cohesive built form with higher densities would have substantially lowered average car ownership, average trip lengths and thus transport-related energy consumption.

In these ways, the issue of transport highlights the fundamental debate over why NGP was developed in its given location to begin with. It follows that this line of thought identifies the Great Park West site as being much more suitable even if the City Council would have been forced to build low density housing stock. Not only would public transit be more viable, but integration within existing neighbourhoods would be vastly improved.

Water

Water consumption per resident is forecast to be 125 l/day. This is quite low, and if this rate can be maintained, water consumption in the development will be efficient. The treatment of local surface water is also a strong point in the development plan as it will help to promote a healthy aquatic environment and thus serve to enhance the local environment. It will also help to enhance high quality green spaces which will promote the area's environmental qualities.

3. Comparing the Stockholm Royal Seaport and Newcastle Great Park Developments

This section compares the main results obtained from the case studies on the Stockholm Royal Seaport and the Newcastle Great Park projects. The aim is to identify common and individual features of the two development projects both in terms of their spatial context and their metabolic performance. Due to differences in the standards used in terms of national statistics between Sweden and the UK, as well as in the availability of indicators for both cases, quantitative comparisons are limited. As such, the following analysis attempts instead to focus on the two projects' role in their particular urban context.

When comparing these two case studies, it is important to bear in mind that each is conceived within a completely different regional development context. Specifically, the city of Stockholm is currently undergoing a process of constant and rapid domestic and international migration while Newcastle has for many years suffered from a slight but ongoing population decrease. Contrasting local perceptions of desirable lifestyles also has very important repercussions on the location and attributes of these projects. On the one hand, in Stockholm there is a strong tendency for people to demand apartments within the inner-city. This is indicated by the very high correlation between property value and proximity to Stockholm's city centre.

However, the situation in Newcastle is rather the reverse of this as local trends have entailed a suburban shift, where neighbourhoods with the highest demand are located beyond the city centre. Therefore, the perceived ideal is to live in single family detached or semi-detached housing that is in close proximity to the countryside and its available recreational amenities. This is indicated not only by the location selected for development of NGP, but

also by the abandonment of various neighbourhoods directly bordering the city centre.

Put together, these diverging characteristics partly explain completely different rationales behind the constructions of these projects. Specifically, in Stockholm new urban developments are a response to satisfying the housing demands of an increasing population while in Newcastle new developments are meant to retain residents who would otherwise re-locate themselves and their tax base to suburban municipalities.

The study area

While the municipalities of Stockholm and Newcastle have in common a rather mono-centric urban structure their true nature is better explained with regard to their differences in respect of urban sprawl. Compared to an average population density of 43 inhabitants per hectare in Stockholm, Newcastle's average density is 24 residents per hectare. In Stockholm, this relates directly to an urban structure that has been developed *vis-a-vis* a public transit-oriented model and with the priority to preserve green space in mind. In Newcastle however, a lower population density and a metro service that does not connect the city's built areas have led to a long-term pattern of urban sprawl, which has been extremely difficult to counter.

Both cities are very different with regard to their energy systems. The main energy source for heating and hot water in Stockholm is district heating while in Newcastle this source is natural gas. Considering that district heating in Sweden is produced from biomass and municipal waste as well as the distribution network is well developed, new urban

developments have a significant advantage in terms of reducing CO₂ emissions and increasing energy efficiency. In fact, the share of renewable energy in the Stockholm region is approximately 48% while in Newcastle is only 1.14%. On the consumer side, the sectoral share of energy consumption of both cities is rather similar, namely, approximately 70% for buildings and industries and 30% for transport.

The consumption pattern of energy for buildings is rather different in both cities due to their very different climatic conditions. Specifically, due to cold winters the average consumption of energy for buildings is higher in Stockholm than Newcastle.

The availability of water resources and the infrastructure for its distribution appear to be sufficient to satisfy further demands in both cities. This is also the case for the waste water collection and treatment systems. *Per capita* water consumption in residences in Stockholm appears to be higher than in Newcastle, specifically 200 and 158 litres/cap/day.

The projects and intervention area

The two projects are completely different in terms of the characteristics of the intervention area. The Stockholm Royal Seaport is a brownfield development constructed on former industrial land adjacent to the city centre while Newcastle Great Park is a green field development constructed on former agricultural land located in the outer peripheries of the city.

The spatial attributes of the intervention areas of both projects can be considered as having a major role in the metabolic performance of both projects. In terms of land use efficiency the Stockholm Royal Seaport is based on the reuse and transformation of already utilised industrial land that no longer fulfilled its purpose. This implies that the economic and ecological functions of green and agricultural areas are not compromised while the performance of urban functions of already exploited land is enhanced. Nevertheless, the population density of the Stockholm Royal Seaport is large, approximately

127 inhabitants per hectare, which is characteristic of dense cities. In contrast, the Newcastle Great Park project, constructed on agricultural land, entails not only that agricultural production is replaced by inefficient urban solutions but also that further land is sealed.

The location of the intervention areas also has significant repercussions on the energy consumed by the transport sector. The location of the Stockholm Royal Seaport lays the foundations for a highly efficient public transport system. The proximity to the city centre makes it possible for residents to reach jobs and services by walking and cycling. Nevertheless, the intervention area already has a public transport system comprising metro, tram and bus lines, which in turn it is planned to reinforce with new tram and bus lines. In Newcastle, the distance to the city centre exceeds five kilometres which makes cycling and walking more difficult for daily commuting. While new bus lines are planned for the area the main mode of transport is expected to be private cars (61% of the trips are expected to be by private car, 11% greater than the municipality).

Once completed, the metabolic performance of both projects will be closely tied to the expected levels of car ownership. In fact the Newcastle Great Park project envisions a car ownership of 0.625 cars *per capita*, almost double as the rest of the municipality. The inverse case is found in the Stockholm Royal Seaport project where car ownership is expected to be no more than 0.185 cars *per capita*, approximately 49% less than the rest of the city (0.364cars/cap). Combined with the good availability of public transport and proximity to the city centre the modal split of car trips is expected to be reduced to less than 38%, compared with the region's average of 47%.

It is undeniable that the implementation of building technologies and small scale energy generation will significantly determine levels of consumption in both projects. Buildings in the Stockholm Royal Seaport project will be constructed with ambitious building standards and cutting edge technologies which are expected to reduce residential energy demand by 72%, specifically, from 196 to 55kWh/m²/year. Savings of approximately 15% are,

on the other hand, expected in the Newcastle Great Park project where energy consumption in relation to dwellings is set to 33.13kWh/m²/year. Another important difference is the expected production of local renewable electricity (sun and wind) which in the case of the Stockholm Royal Seaport project is envisaged at 30% of the consumption of electricity, while in Newcastle this figure is only 1.36%.

Water consumption by households in both development projects is expected to fall below the city average; in Newcastle -21% and in Stockholm -50%. Water saving measures are however similar in both development projects as they are achieved by the installation of water saving devices and water efficient appliances. Though, the use of storm water for irrigation is unique to the Stockholm Royal Seaport project. In the Newcastle Great Park development irrigation is regarded as a potential problem as house gardens may require more water than expected. The greatest contrast is likely to be found in terms of wastewater management solutions because the Royal Stockholm Seaport development will use the sludge from wastewaters for biogas production.

At first glance the main impacts of these urban development projects on energy and water consumption levels do not appear to put too much of a constraint on the existing infrastructure and the availability of these resources in both cities. The reason is simply that the number of new residents in these developments is just a fraction of the total population. In the case of Stockholm it is also likely that the impact may not be that visible because the city is expected to be more energy efficient. This may also apply to water consumption and the generation of wastewaters.

Not considered in the case studies, but important to bear in mind especially in the case of Stockholm, is that several other development projects are currently taking place at the same time in the city. This suggests that the impact of the development project may be significantly higher compared to the demands put forward by ongoing new urban development projects in the city.

Consumer behaviour perspectives on urban metabolism

The extent to which consumers are willing to adapt to a more resource-efficient lifestyle and to which technologies may be able to contribute is a key question. As explained in the case of the Stockholm Royal Seaport project, what is technically possible in this regard does not necessarily mean that the goals set for the Stockholm Royal Seaport are possible to achieve. The reason lies in the complexity of habits, behaviours and cultures among people. The situation is similar in Newcastle where it was established that much of the energy saving potential hinges on the consumer habits of homeowners, where energy analysis of completed homes showed lower than optimal resource efficiency due to the consumption behaviours of residents.

Accordingly, both projects face a common challenge where the residents moving into these two areas will have relatively high incomes. Considering that households with higher incomes correlate strongly to increased energy consumption (along with larger living spaces) in both MIA's the implementation of informative and monitoring measures will be central to achieving the targeted goals.

Strategic perspectives on new urban developments

As confirmed at the beginning of this section, these development projects emerge as two very different strategic responses to contrasting regional contexts, in Stockholm to provide new residences to a growing population while in Newcastle to attract new residents.

The case of the Newcastle Great Park project clearly illustrates how sustainable urban development goals enter into conflict with market forces in

housing. In the UK this situation is particularly true where regions with declining populations are today offering single family houses closer to the countryside. This phenomenon does not come from a vacuum but rather from cultural ideals, increasing income and still relatively low fuel prices. This does not only characterise the UK but is also found in many other locations in Europe. An example of this is Nyköping in Sweden, a mid-sized city of around 30,000 inhabitants about 100km south of Stockholm which is also suffering from outmigration. Here the municipality launched a campaign offering ideal single family houses for lower prices in order to attract people from neighbouring regions but mainly from Stockholm.

It is clear that the Stockholm Royal Seaport project is in-line with the city's sustainability goals as regards densification, connectivity and climate change mitigation and adaptation. However, it is important to acknowledge that this project is also largely driven by market forces. This is exemplified by the implementation of advanced technologies in attractive areas, such as Hjorthagen, where the price of real estate is high enough to cover the costs of these technologies. This may, in part, explain why equally ambitious environmental urban development projects are not found in the suburbs where real estate prices are appreciably lower.

The Stockholm Royal Seaport project also plays an important role in the urban development of the city because it functions as a strategic measure to implement new technologies and urban models which, in turn, could be implemented in other locations across the city. Nevertheless, it is expected that this process will also lead to the foundation of new export industries in green technologies.

4. The application of MIA as a planning tool

According to its developers MIA was not only designed as an assessment tool for research but also intended to become a decision support tool for practitioners in planning. On the basis of the experiences obtained in the implementation of the MIA approach in the case studies on the Stockholm Royal Seaport and Newcastle Great Park projects, this section aims to explore its applicability as a planning tool by checking its compliance with the basic decision making criteria applied in Environmental Impact Assessment (EIA) as well as identifying the synergies and differences between MIA and EIA practice in Sweden and the UK. The following analyses have a particular focus on the scoping process in EIA. The goal is to use these findings as the baseline for recommendations intended to help in the process of developing MIA into a practical tool in planning.

Metabolic approaches, EIA and SEA in Sweden and the U.K.

Sweden

Both the EIA and SEA (Strategic Environment Assessment) procedures in Sweden are found in the Environmental Code, the Building and Planning Code and the European EIA¹⁰ and SEA¹¹ Directives (85/337/EEC and 2001/42/EC). Starting with the EIA Directive article 4 and the SEA Directive article

2C, EIA and SEA shall identify describe and assess the direct and indirect effects of a project on human beings, biodiversity, *fauna* and *flora*, soil, water, air climate and landscape, material assets and cultural heritage and the interaction between the above-mentioned factor.

The Environmental Code is extensive with regard to the content and procedures on impact assessment. Alongside with the elements considered in the European EIA legislations, the assessment of the effects of a project on the physical environment and the access to land, water, raw materials and energy is also required. This implies in the scoping process that the consideration of impacts not only includes traditional environmental aspects such as air quality and biodiversity but also, if required, that the impacts on the availability of resources such as land, energy and water are investigated

In Swedish EIA practice an integrated understanding of the environmental impacts shall be provided. This requires that in the scoping process the interactions between various environmental aspects are described and analysed, not only in the intervention area but also in its surroundings. The intervention area's functions and interactions with other areas should thus also be clarified. This means that the geographic scale of EIA can on occasion go beyond the border of the intervention area (Hedlund & Kjellander, 2007).

The character and the number of issues investigated in relation to Swedish EIA practice depends entirely on the characteristics of the project proposal. The EIA shall focus on the most relevant issues and exclude those that will have less significance in order to enhance accuracy and efficiency in the planning process (Hedlund & Kjellander, 2007).

The baseline for the scoping process is often found in the consultation processes. Specifically, the

¹⁰ Council Directive 85/337/EEC of 27 June 1985, on the assessment of the effects of certain public and private projects on the environment.

¹¹ Directive 2001/42/EC of the European Parliament and of the Council of 27 of June 2001 on the assessment of the effects of certain plans and programmes on the environment.

opinion of the public, government institutions and other stakeholders on the environmental impacts related to a project are considered among the most important criteria of how the impacts are evaluated, and which elements are given priority (Hedlund & Kjellander, 2007).

Being an integral instrument in Swedish planning EIA practice implies that plans stipulated by the Planning and Building Act are taken in consideration in EIA. In EIA practice projects are not only evaluated against detail and comprehensive plans at municipal level but often against strategic goals set at regional and national level. In this respect EIA seeks to relate a project's impacts and strategic relevance to these goals. At national level a project proposal is often evaluated based on sixteen environmental quality goals which relate to the state of the environment in terms of climate change, resource efficiency and biodiversity among others. Despite of these goals are not legally binding they can be steering for different actors' activities. Other important criteria used in Swedish EIA are the so called Environmental Quality Standards, which relate to legally binding limits on air and water quality and noise.

The United Kingdom

Just as in Sweden, EIA and SEA procedures in the UK are based on compliance with the European EIA and SEA Directives for the impact assessment of projects. These directives are transposed into UK legislation through the Department for Communities and Local Government. However, in the UK there is a clear scalar approach where the SEA is meant to assess larger scale plans, strategies and programmes while EIA pertains to individual development projects. As such, there are situations where a project may have an EIA but no SEA, but no situations where an SEA would exist without more detailed EIA's for individual projects within larger plans.

In the UK the SEA is based on the Environmental Assessment of Plans and Programmes Regulation 2004¹². In fact, though usually referred to as an SEA it is formally titled as

an "environmental assessment" of certain plans and programmes prepared by an authority at the national, regional, or local level (ODPM, 2005). In particular, this relates to any project proposed for agriculture, forestry, fisheries, energy, industry, transport, waste management, telecommunications, tourism, town and country planning, or land use AND which set the framework for future development projects requiring consent within the European EIA Directive mentioned above. In this context, a local development framework, such as the one proposed (and subsequently rejected) in 2008 for Newcastle would require an SEA (ODPM, 2005).

In the UK the EIA is based on the Town and Country Planning (Environmental Impact Assessment) (England and Wales) Regulations 1999¹³, which has transposed the European directive from the same year. Due to the fact that, compared to an SEA, an EIA is geared towards the assessment of individual projects taking place within plans or programmes; the "competent authority" passing judgment on EIA submissions is the local planning authority in a given area (DCLG, 2000). In a very broad sense, the UK Secretary of State mandates that an EIA is required based on three criteria:

- Major developments which are of local importance;
- Developments which are proposed for particularly environmentally sensitive or vulnerable areas;
- Developments with unusually complex and potentially hazardous environmental effects. (DCLG, 2000)

An integrative approach in the assessment of environmental impacts is also present in EIA in the UK. This implies that EIA shall consider the interrelationships between e.g. population, *fauna*, *flora*, soil, water, air, climatic factors, material assets and landscape. In addition, it is also required to consider the secondary, indirect and cumulative impacts that may arise as a result of a development and its proximity to other lands uses. The implications of this are twofold. On the one hand,

¹² Statutory Instrument 2004 No. 1633

¹³ Statutory Instrument 1999 No. 293

the EIA is an iterative process: information gathered during the early stages may need to be revisited in light of new information discovered later. On the other hand, the spatial extent of the study area (impact area) depends on the scale and distribution of each of the impacts of a development (Environmental Agency, 2002).

The number of issues investigated in EIA depends on the characteristics of the project investigated. Here, the scoping phase identifies key concerns (potential impacts) of projects, but is carried out at an early stage, ideally during the site-selection process, so that mitigation measures can be incorporated into project designs (Environmental Agency, 2002).

However, scoping is also designed to increase efficiency within the EIA process. By investigating the key impacts of a project it should progressively consider a decreasing range of issues, but in increasing detail and in line with the expected impacts of the project. In so doing, a balance is struck between incorporating the most important impacts of a project and eliminating those that will have less significance. Thus, an effective scoping exercise should ensure that assessments focus on the relevant environmental issues while not allocating disproportionate resources to minor issues (Environmental Agency, 2002).

Basic differences between MIA and EIA

According to its developers at least five basic differences distinguish MIA from EIA (Pinho *et al*, 2010):

1. *The geographic scale:* The study area in MIA coincides with the borders of a city or urban area for which the assessment “urban metabolic” model is available. In EIA the geographic scale of the study area tends to be constrained to the borders of the intervention area though on occasion it is defined by the attributes and the scale of the impacts of the project proposal.
2. *Applicability of plans and projects:* MIA is applicable to the assessment of both projects and plans while EIA is applied specifically to projects. Due to the complexity embedded in metabolic processes in cities however, the application of MIA on plans is more difficult.
3. *Integrative approach:* While MIA deals with environmental components in an integrated way according to the notion of metabolism, EIA tends to be “artificially fragmented” into several components.
4. *Timeframe:* MIA can be performed *ex-ante* and *ex-post*. However, it is better suited to short-term analysis. EIA is essentially an *ex-ante* exercise and can be applied to longer time frameworks.
5. *Legality:* MIA is not subject to a legal or regulatory framework but it can be incorporated into the planning process. EIA on the contrary, has a specific legal basis in planning.

An important additional attribute that distinguishes MIA from EIA is that MIA addresses the urban form. In other words, MIA seeks to evaluate the “metabolic” performance of a project based on the spatial location in the study area. This *rationale* stems from the SUME project as MIA aims, among other things, to find correlations between urban form and the consumption of energy, water, land and materials in a particular project. Specifically, the urban form has been addressed in MIA not only by identifying the spatial dimension of the impacts of a project proposal but also by incorporating scenarios of alternative locations of a project proposal.

The review, undertaken above, of the metabolic issues raised in EIA practices in both Sweden and the UK sheds light on further new aspects that not only relate to, but also further differentiate, both approaches. The following section will analyse MIA in greater detail and particularly in respect of the decision making criteria used in EIA.

MIA compliance with decision making criteria

Despite the fact that MIA and EIA share the common objective of assessing project impacts, the application of MIA as a planning tool does not have a legal character. Considering the level of complexity in planning practices however, it is important that MIA retains the basic criteria used in EIA for decision making. This is necessary if MIA is to have the potential to complement EIA. It is however relevant to point out that MIA and EIA should be thematically differentiated in order to avoid the risk of unnecessary cost due to the overlapping of tasks.

The intention of this section is thus to scrutinise the MIA approach against the EIA criteria in order to determine whether MIA is performed under the premises necessary for decision making in planning and to determine how these tools are differentiated.

According to Hörnberg C. (2005) a genuine EIA complies with the seven basic criteria used here to evaluate the MIA methodology:

1. The *decision-making criterion*: means that the EIA must be prepared prior to the decision and serve for the decision-maker to weigh the environmental consequences of alternative solutions in a project. An EIA should therefore enhance knowledge and understanding about the environmental impacts a project's alternatives will bring to an intervention area. EIA should be based on objectivity and science through the use of accurate assessment methods that can be reviewed and understood by stakeholders. An EIA should, at an early stage, identify and address the most relevant issues of an intervention rather than endeavour to be too extensive and general. EIA should include information on the localisation and the geophysical and ecological characteristics of the intervention area as well as its environmental sensitivity.

MIA clearly has its foundations in the decision making criterion because it seeks to increase knowledge and understanding of the impacts of a particular project proposal in the initial phase of planning. MIA is however thematically more

restricted as it focuses on specific “metabolic” aspects relating to the urban form; namely land, energy, materials and water, rather than being open to any environmental aspect as regards a particular project. In this respect the MIA investigates, in a more in depth manner, each of the components and their subcomponents while in EIA the choice and the level of detail at which the components are analysed depends on their relevance to the project's impacts and the sensitivity of the study area. Another difference is the geographic scale of the assessments in the MIA which not only covers the impacts on the intervention area but also those on the surrounding urban area (study area). MIA thus demands good accessibility to models and data on a larger geographic area.

2. The *objective criterion*: implies that the purpose of the project proposal or activity must be specified in the impact assessment in order to clarify the needs of the activity in a particular location. This criterion is also of crucial weight in relation to which alternatives are eligible.

One of the main strengths of MIA is to be found in the compliance with this criterion because it not only implies the evaluation of a project against the “metabolic” characteristics of both the intervention and the study area, but also against the strategic goals set in a city or region. In other words MIA helps to relate and understand the interactions between the project and the study area, evaluates the impacts and tells us how the impacts could contribute to, or block, the attainment of these strategic goals.

3. The *alternative criterion* requires investigating the consequences, not only of the project, but also of alternative ways of achieving its purpose. It follows that a comparison between the different options regarding environmental impacts as well as an assessment of the consequences, where the project is not executed, the so-called zero-alternative, are undertaken.

The alternative criterion is also present in MIA but mainly in relation to the choice of alternative locations. The MIA methodology presented in Chapter 1 also mentions that alternative scenarios,

on the basis of the project's characteristics, could be included. An important contrast here is however that MIA does not address the evaluation of a zero-alternative. MIA also results in recommendations aiming at the mitigation of the negative impact(s) of a project.

4. The *environmental impact criterion* requires that all significant environmental impacts of the activity are reported. The aim is to provide an overall picture of the consequences which will include both the direct and indirect impacts of activities, e.g. effects that are specific to the particular intervention area. The impacts in terms of downstream services, such as raw material and energy consumption, should be included in the assessment.

As noted previously, MIA is orientated towards the evaluation of the state and the impacts of flows and stocks of materials, water and energy while EIA has a wider scope of elements covering the impacts of any significant environmental aspects. MIA also has an integrative approach because it aims to highlight the interdependencies between the various elements evaluated. Per definition, EIA has an integrative approach, despite not always being the case in its implementation. The main difference however is that MIA addresses these interactions from a metabolic perspective, implying that the impacts are analysed from a metabolic (cyclical) processes in the flow of land, energy and water.

5. The *comparability criterion* implies that the contents of the EIA can be used to compare the various alternatives and to weigh the different consequences against one another.

The fact that MIA can be used as a research tool implies that it is designed not only to compare alternative scenarios and their consequences but also to allow for the comparison of several independent projects. This implies that MIA has a much higher degree of standardisation than traditional EIA.

6. The *openness criterion* ensures the transparency required in planning processes and that stakeholders have opportunities to participate.

As MIA is not a formal planning tool however public participation procedures are not provided in the guidelines. The structure and content of MIA however presents an extensive review of evaluation models and data at different geographical scales which may enhance transparency in the scoping and assessment processes.

7. The *review criterion* stipulates that it should be possible for anyone interested to examine the contents of an impact assessment. This aims to secure the involvement of all involved stakeholders and actors but also to minimise costs for both the operator and the community, because it prevents conflicts and misunderstandings emerging during the planning process.

Since MIA does not have any legal weight, this criterion applies only to the capacity of the methodology to result in documentation that is understood by end-users. As discussed below this is one of the main challenges that MIA needs to overcome before becoming a fully functioning decision making planning tool. This is particularly relevant because the methodology and the structure of the assessments in an MIA are highly technical and often difficult for some stakeholders to understand.

MIA and EIA: synergies and contrasts

It is clear that MIA and EIA share the basic criterion for decision making in planning as they both serve as a knowledge base for decision making and the quest for objectivity. The previous section also shed light on how the MIA complied with other basic principles including the objective, the alternative and the comparability criteria. On the other hand, MIA and EIA remain very different not only in the choice of their components (scoping) but also in the depth and geographic scales of the evaluations. The assessment of elements such as energy can however, on occasion, be addressed in the context of EIA but

this is often only on a very general level within the context of climate change mitigation. Paradoxically, consideration of these elements could be extensive in e.g. Swedish EIA practice in cases where they are critical relative to the impact of a project or the characteristics of the intervention area.

Consideration of national and other relevant policy goals in the evaluation of the impacts in a particular study area is also present in EIA practice. At least in Sweden, policy goals at different governance levels are often set as a means to enhance reliability and strengthen a project's strategic relevance.

A major contrast is to be found in the larger geographic scale at which the impacts are evaluated in the context of MIA. Detailed quantitative information of the study area and the intervention area are necessary to realise a comparative analysis between the alternative development projects and resource consumption patterns taking place within the study area. Nevertheless, MIA is mainly quantitative while EIA in practice allows for the implementation of both quantitative and qualitative assessment models.

Despite MIA being intended to be more integrative than EIA, the experiences obtained during its application in the two case studies outlined above proves that this is not necessarily the case. In fact EIA is by definition integrative as expressed in national and EU legislation. However, the problem in adopting an integrative approach is the inherent complexity of the interactions within natural systems. This complexity constrains EIA practice in terms of the development and application of assessment models. This situation was actually experienced in the application of the MIA which resulted in sectoral results, where only a few reflections were considered in terms of the inter-linkages between the issues investigated.

Recommendations on the practical application of MIA in urban planning

The discussion in the previous chapter suggests that MIA has the potential to serve decision making in urban planning. A clear differentiation between MIA and EIA regarding their components can be considered central in avoiding excessive documentation and costs. MIA's compliance with the decision making criteria used in EIA helps in the use of MIA in planning processes as it follows a rationale that is familiar for planners.

The practical application of MIA relies on its capacity to become a reliable and cost-effective communication and decision making tool for end users, including planners, developers and the public in general. Achieving a high degree of versatility when applied by the institutions responsible for making impact assessments is also essential in reducing costs.

On the basis of these assumptions and the findings presented in this working paper the MIA approach partly complies with these basic requirements because it:

- captures the context (status quo, trends and strategies) of a study area and addresses both direct and indirect impacts in relation to the context of various geographic scales in the early phases of planning. This approach enhances understanding of the character and scale of the impacts and their strategic relevance.
- provides a better understanding of the challenges put forward by new development projects and identifies potential bottlenecks in the flows and stock of energy, material, water and land. As such, MIA certainly provides early signals to decision makers and the public regarding the need for new infrastructure and solutions for making the use of resources more efficient.
- is compatible with the criteria used in EIA. Therefore MIA and EIA could be carried out simultaneously in a complementary manner, and in close cooperation between actors from several disciplines. This could save time and costs not

only due to the reduced risk of overlap but, most importantly, because of the increased reliability of the assessments which, in turn, reduces the risk of misinterpretation and the lack of information in decision making.

- combines approaches from different planning disciplines such as urban, energy and transport planning in a single document. MIA can thus be viewed as a robust and broad foundation for decision making in planning.
- is a tool that complies with today's planning demands. Climate change and natural resource depletion are clearly a threat for urban areas, which implies that urban planning needs new tools that enhance understanding on the best ways to support resource efficiency, reduce greenhouse gas emissions and prevent natural disasters. Both the metabolic and anticipatory approaches in MIA respond well to all of these demands.

On the other hand MIA is likely to face several challenges before it can be adopted as a planning tool. As such, the work on improving the MIA methodology should:

- provide a simpler structure when applied and reported such that it can be understood by a wider range of users including the public. This is particularly important considering that the sequence of steps involved in the MIA is relatively difficult to follow due to the many repetitive steps involved. Therefore, some steps should be merged in order to concentrate the information in a more concise manner.
- simplify the scoping criteria in the selection of the assessment models and indicators. The utilisation of qualitative methodologies should also be considered as an alternative to quantitative models.
- place more emphasis on compliance through strategies and sustainability criteria rather than focusing mainly on technical performance. In other words, assessment models could be selected according to their relevance rather than quantitative accuracy.

- put more emphasis on the 'soft' aspects of metabolic processes such as consumer behaviour, culture, social integration etc. Often these aspects play a central role in metabolic processes in urban environments. Nevertheless, they often explain the interrelations between the metabolic components investigated.
- take greater account of the cumulative effects of other ongoing urban development projects within the study area. In both case studies the impact of the individual projects did not appear as significant as involving a small fraction of the total population in the study area. Taking the cumulative effects of other urban development projects will certainly reveal major implications.
- put more emphasis on the re-incorporation (cyclical processes) of materials, energy, land, etc. This remains challenging because of the high level of complexity in metabolic processes in urban areas as well as the lack of available data necessary to make accurate quantitative analyses of flows and stock at different geographic scales. This implies that the level of ambition in the execution of the MIA is dependent on the level of resources available to evaluators. More flexibility in the number of components, the methodology and the level of detail could therefore make the application of MIA more resource-efficient.

An important reflection here is that the geographical multi-scale perspective along with assessments of many components and indicators makes MIA a complex and time-consuming assessment tool. Given the level of cost generated by these characteristics MIA is placed at a serious disadvantage relative to other assessment tools based on Environmental Accounting such as Life Cycle Analysis and Material Flow Analysis.

It is thus clear that if it is to be used more broadly MIA must become simpler to use and implement and thus, ultimately, more coherent rather than more extensive. Specifically, MIA should endeavour to crystallise into a document that describes and communicates the "metabolic" impacts of projects and plans in an effective, coherent, reliable and cost-

efficient manner. It is also important to bear in mind that the synergies and differences between MIA and EIA should be considered more fully in order to avoid overlap and inconsistency where they are undertaken for the same project.

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Chapter 2 & 3- Newcastle Great Park

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Annex I

Stockholm Royal Seaport

Operative targets in the Stockholm Royal Seaport

Table 4. Operative targets in the Stockholm Royal Seaport (City of Stockholm, 2010)

Climate adapted green- and recreation spaces ▪ The district shall be tailored to meet future high sea levels due to changing climate. ▪ Rainwater shall be harnessed for irrigation and then brought to the urban wetlands and damp areas. ▪ Each property and public spaces shall comply with standards for green space specified by the City Administration. ▪ Green surfaces shall be tailored to local conditions in each area. Land and seabed sediments in dock and beach environments shall comply with environmental quality standards. ▪ Storm water Management shall contribute to the achievement of good water quality in Husarviken and Värtan.
Sustainable energy ▪ All systems, installations and devices in buildings, infrastructure and transport should have verified very low energy consumption. ▪ The energy system in the Stockholm Royal Seaport shall be efficient and climate-positive, primarily based on a fossil-fuel-free CHP system. ▪ Smart energy networks will be developed in the Royal Seaport based on the purchase and sale of renewable energy between the power transmission grid and individual buildings. ▪ All the electricity used during the construction and in the infrastructure (e.g. street lighting and traffic signals) should be labelled as environmentally and climate-neutral. During the management phase long-term supply contracts of environmentally certified and climate-neutral electricity should be established between managers of residential / commercial premises and power suppliers. ▪ Regular monitoring of energy use and its impact on climate will take place in buildings, households and activities, as well as transportation infrastructure. ▪ Buildings should have very low energy consumption endeavouring to develop the so-called 'plus houses' in the area. ▪ Individual properties will generate their own electricity based on renewable energy and deliver a surplus to the smart grid. ▪ Active concepts for comfort cooling should be avoided. In the first instance solutions that minimise cooling requirements such as fixed solar shading and solar control glass. If such measures are not sufficient, passive concepts for comfort cooling can be used.
Sustainable recycling systems ▪ The amount of household waste generated <i>per capita</i> will be significantly lower compared to the rest of the city. Recycling centre / Mini-AVC will be created in the area in a collaboration between businesses, property owners, residents and recycling contractors. ▪ All food waste from homes, restaurants, catering, shops, ferries and other activities should be recycled through biological treatment to produce biogas, returning nutrients back to the soil. ▪ The degree of recycling of waste shall be very high in homes and businesses. ▪ Bulky waste will be re-used, recycled or transformed into energy. ▪ Hazardous waste shall not be present in household or bulky waste. ▪ The collection of waste shall facilitate the separation of paper, packaging, glass, plastic, metal and cardboard as well as food, combustible, bulky and electronic waste, in apartments, other buildings and in public spaces. Special emphasis will be on the collection of hazardous waste, organic waste materials, and products bound to producer responsibility. ▪ The transport system for waste shall be energy efficient and climate-neutral. ▪ Regular monitoring of waste generation shall take place. ▪ The amount of construction waste shall be minimised, sorted, recycled and documented. ▪ Waste generation from public spaces shall be separated and recycled to a large extent.
Sustainable water management system ▪ The water supply shall be integrated into the city's drinking water systems. Water consumption <i>per capita</i> shall be lower through the deployment of water-saving technologies in buildings as well as through the collection of storm water for irrigation and other needs that do not require high water quality. ▪ Sewage and bio-waste systems shall have a high degree of purification. ▪ The content of nutrients in sewage should be returned to productive agriculture land. The concentration of heavy metals and other pollutants shall be below levels that allow for the reversal of bio-solids and nutrients to agricultural land. ▪ The water and sewer systems will have an optimal capacity to recovery energy (biogas and waste heat) and shall be based on energy-efficient technologies. ▪ Sewer systems should be adapted to cope with future increases in water levels.

- Regular monitoring of water use shall take place in buildings, homes and businesses.
- Charges for water and sewage will encourage residents and businesses to rationalise water and avoid the disposal of toxic substances in sewers.

Sustainable transport

- Residents and workers shall in the first instance walk, cycle or take public transport to go to school or work.
- The road environment shall be designed so that car traffic in the area is limited through the design of the traffic network.
- The street network for pedestrians should be continuous throughout the area. Low speeds, wide pavements, pedestrian streets, directions and measures to improve ease of orientation etc., shall be used to attract pedestrians.
- Attractive bicycle parking shall be available both in connection with the buildings, at public transport hubs, jobs and services.
- Bicycle lanes shall be linked to the existing cycle lane network and where necessary, this network shall be strengthened or expanded.
- Public transport must be attractive and provide good accessibility. Public transport shall consist of trams, subways, buses and boats; and will link the various parts of the district to important destinations in the city.
- Public transport, walking, cycling and 'car-pooling' will be competitive alternatives to private car transportation. Residential parking will be located in specific places while street parking shall be organised only for the purpose of visits and car-pooling.
- Car pools with environmentally friendly cars and bike pools will be available to residents and workers in the district. Access to parking lots for these vehicles will be placed in strategic locations.
- Residents and workers in the area shall be offered a personal travel plan in order to minimise their transport needs. Residents should be offered a one-year membership in the car pool by the building developer.
- A logistics centre will be established as part of a sustainable transport network adapted to goods transport. Goods transport shall take place by means of environmentally friendly vehicles. Activities in the area shall minimise travel through service centres and through the establishment of transport plans.
- Information and communication technologies shall be used to reduce and optimise travel.

Environmentally adapted residences and locals

- Buildings and infrastructures in the district shall be adapted to future climate change in terms of rising sea levels, the disposal of high rain water as well as a wetter and warmer climate and the risk of local flooding.
- Buildings and properties shall be environmentally designed in an integrated way in order to achieve energy efficiency, sound management of resources, minimal environmental impact and good health and comfort while providing the bases for environmentally efficient transportation, sustainable lifestyles and social activities.
- Buildings shall be designed with materials and products that are documented as good environmental, health and energy choices and reusable.
- Any environmental impact as well as energy and resource consumption shall be minimised during construction. Buildings shall offer a healthy and comfortable environment with low-emission building materials, moisture protection and low noise levels while being aesthetically pleasing to the public.
- Buildings should have very low energy consumption aiming at developing so-called 'plus' houses that generate their own renewable energy.
- Buildings and infrastructure shall be water efficient
- Residential and commercial buildings will contain user-friendly system for individual measurement, visualisation, reading and control of energy, water consumption and waste generation.
- Building and property should contain visible bicycle parking in attractive locations, have few parking lots for cars and have charging stations for electric vehicles in parking spaces.
- Buildings and parks shall promote sustainable lifestyles. Areas shall be provided with vegetation and be a good outdoors environment for play and all sorts of outdoor activities.
- Buildings will provide common areas and meeting places for different needs and interests of residents and associations.
- Public buildings will be at the forefront in environmental adaptation while exhibiting architectural finesse.

Sustainable lifestyles

- All tenants and condominium owners shall at first contact with the building company be informed about the aim of developing a sustainable living and lifestyle environment
- On moving in, all tenants and condominium owners will be offered an introductory programme on sustainable living and lifestyle.
- Prior to each deployment stage, a special planning document for sustainable living and lifestyles shall be created.
- Buildings and infrastructure, such as parks, housing estates of activities and rooms for social meetings, should be completed by the time new residents settle in the area.
- A system for the rental of vehicles, boats and other durable goods suitable for hiring should be available in the Royal Seaport.
- Good access to meeting places should be available in the area
- Parks, green spaces and water areas shall be made available.
- The area shall provide a rich variety of opportunities for the practice of sports, physical training, health activities.
- The old industrial environments of the gasworks area shall be a resource for cultural and social activities for the residents.

Characteristics and energy consumption of new buildings and the current infrastructure in Hjorthagen

Table 5. Characteristics of new buildings and the current infrastructure in Hjorthagen

Development	Nr. of residents	Residential space (m ²)	Office, commercial and cultural space (m ²)	Schools (m ²)	Total area (m ²)
Västra	2,500	112,195	2,674	1,690	116,559
Norra I	1,750	72,186	588	1,248	74,022
Norra II*	1,250	58,810	2,460	0	61,270
Norra III*	2,100	91,106	777	1,452	93,334
Norra IV*	3,250	140,997	20,000	2,247	163,244
Gasklocka III&IV	1,000	70,000	3,370	691	74,061
Kulturscen	0	0	3,000	0	3,000
Business park (Gasworks)*	0	0	20,000	6,000	26,000
Ängsbotten*	600	3,000	10,000	0	13,000
Rådjurstigen**	750	32,538	277	518	33,334
Elektriciteten**	500	21,692	185	346	22,222
Subtotal Royal Seaport	13,700	602,524	63,331	14,192	680,047
Old Hjorthagen	2,151	76,325	31,336	na.	107,661
Total	15,851	678,849	94,667	14,192	787,708
* Detail plans are missing. Estimations based on the characteristics of the developments in Västra and Norra I and the number of residents assigned for each development.					
** Development areas where no decision on their construction has been made.					

Table 6. Estimated energy consumption of new buildings and the current infrastructure in Hjorthagen

Development	Residential heat kWh/year	Residential electricity kWh/year	Non-residential heat kWh/year	Non-residential electricity	Total energy consumption kWh/year
Västra	6,731,700	1,682,925	261,840	184,400	8,860,865
Norra I	4,331,160	1,082,790	110,160	66,840	5,590,950
Norra II*	2,352,400	882,150	123,000	123,000	3,480,550
Norra III*	3,644,236	1,366,589	111,424	82,389	5,204,638
Norra IV*	5,639,889	2,114,959	1,112,335	1,067,401	9,934,584
Gasklocka 3&4	2,800,000	1,050,000	203,065	239,789	4,292,854
Kulturscen	0	0	150,000	195,000	345,000
Business park*	0	0	1,300,000	1,180,000	2,480,000
Ängsbotten*	120,000	45,000	500,000	500,000	
Rådjurstigen**	1,301,513	488,067	39,794	29,425	1,858,799
Elektriciteten**	867,675	325,378	26,529	19,616	1,239,199
Subtotal Royal Seaport	27,788,574	9,037,858	3,938,147	3,687,860	44,452,439
Old Hjorthagen	11,770,917	3,053,000	4,658,956	3,196,272	22,679,145
Total	39,559,491	12,090,858	8,597,103	6,884,132	67,131,584
* Detail plans are missing. Estimations based on the characteristics of the developments in Västra and Norra I and the number of residents assigned for each development.					

Estimations on transport

Table 7. Modal split and number of trips by transport mode generated by the new developments in Hjorthagen. No measures or policies are considered. (Values assessed by using the transport model presented by Karin Modig *et al.* 2005)

Modal	Modal %	No. Trips Residents	No. Trips Workers	No. Trips Visitors	No. Trips Total
Pedestrian	15%	5,460	1,200	600	7,260
Bicycles	6%	2,184	480	240	2,904
Car	47%	17,108	3,760	1,880	22,748
Public transport	30%	10,920	2,400	1,200	14,520
Other	2%	728	160	80	968
total	100	36,400	8,000	4,000	48,400

Table 8. Modal split in Hjorthagen in 2020. (19% reduction on car trips)

Modal	Modal split (2020)	Number of trips
Pedestrian	16%	8,057.6
Bicycles	10%	5,036
Car	38%	19,136.8
Public transport	34%	17,122.4
Other	2%	1,007.2
total	100%	50,360

Modal split has been set considering the potential of individual measures expressed in the plans, the location of the area and current transport patterns. The values are not tested in models and therefore are meant only to exemplify a reduction of 19% in car trips.

Standard calculations on the consumption of heat and electricity (Stockholm MIA)

Estimations on energy consumption for local (services) and residential buildings and houses are based on the area of these entities for each individual planning area, or “*Basområden*” in Swedish. The areas are multiplied by the average energy consumption per m² for heating and electricity which are calculated separately depending on the building typology. The floor areas of non-residential and residential buildings are obtained from the data package FASTPACK, as produced by Swedish Statistics for 2004. The averages for the consumption of heat and electricity have been extracted from publications by the Swedish Energy Agency.

The estimation on electricity comprises all electricity consumption except for heating and warm water, which is instead included in the estimations on heat as later described. For locals, the average used as a coefficient for the estimation on electricity consumption was 102kWh/m²/year. This corresponds to the average for office consumption in Sweden as shown in Table 9 (Swedish Energy Agency, 2010). The reason for not using the other coefficients for hospitals, schools and sport halls was because the typologies were not possible to track in the data set from FASTPAK. Considering that most of the non-residential buildings in the City of Stockholm are used as offices, public administration, and other related services it was more appropriate to use the average consumption of offices. Though, considering that this coefficient is higher relative to the other typologies it is expected that the estimations presented in this report are higher, especially in suburban areas where the use of local space is more diversified, for instance workshops, storage, schools, etc.

The coefficient for the estimation of the electricity consumption of households was 40 kWh/m²/year in Table 9 (Swedish Energy Agency, 2009c), which corresponds to the average consumption in Sweden. This coefficient also excludes the use of electricity for heating and warm

water. For this estimation, the use of the average consumption per inhabitant was also considered by using the figures presented in the report entitled “*End-use metering campaign in 400 households in Sweden*” (Zimmerman, 2009). These figures do however vary depending of the housing typology, the composition of the families and group ages of the residents in buildings. Due to the degree of detail of this approach one may consider the use of these coefficients more accurate than using the average consumption by m². However, the lack of this information in FASTPACK did not allow for the assignment of the age group or the composition of the families living the houses. Therefore, use of the average consumption of electricity by m² was considered more appropriated.

Calculation of the consumption of heat for service, commercial and industrial buildings different coefficients (see Table 10) for the average consumption for different building ages in Sweden were used (Swedish Energy Agency, 2009a). The decision to use the average consumption for all typologies (activities carried out in the buildings) was based on the same rationale as for electricity, specifically in determining the different housing typologies in the data base. This implies that the results obtained imply some degree of inaccuracy.

Heat consumption of residential buildings was not only estimated according to the age of the buildings but also the housing typologies (Swedish Energy Agency, 2009b & 2009c), which correspond

Table 9. Consumption of electricity excluding heating and warm water by m².

Type of building	Consumption (kWh/m ² /Year)	Source
Schools	62	Swedish Energy Agency (2010)
Hospitals	78	Swedish Energy Agency (2010)
Offices	102	Swedish Energy Agency (2010)
Sport halls	129	Swedish Energy Agency (2010)
Dwellings	40	Swedish Energy Agency (2009c)

to single family houses (Table 11) and multi-dwelling buildings (Table 12). Areas of secondary buildings, for instance garage and storage facilities,

for single family houses were not included in the calculations as those are generally not heated nor do they serve as residential buildings. Compared to the estimation on non-residential buildings, the estimated heat consumption of residential buildings should be more accurate.

Table 10. Average energy use (excluding cooling and electricity for cooling) for heating and hot water per m² of heated area of the premises in 2007, broken down by type of buildings and when built, kWh/m². (Swedish Energy Agency, 2009b)

Year of construction/Type of local	-1940	±	1941-1960	±	1961-1970	±	1971-1980	±	1981-1990	±	1991-2000	±	2001-	±	Data missing	±	All	±
Residential buildings	145		149		178		140		118		110		120		146	11	136	14
Hotels and student residences	155		175		128		159		149		140		147		154	57	149	9
Restaurants	166		168		137		164		139		146		132		135	32	152	12
Offices	119		114		114		111		89		99		106		115	12	108	3
Grocery stores	154		96		117		172		211		148		105		110	13	147	15
Trading	139		116		112		110		104		77		97		130	34	110	6
Healthcare, day and night	153		140		148		130		124		137		105		165	20	141	6
Other healthcare	153		120		148		146		153		134		99		137	31	142	9
Schools and universities	153		141		146		142		120		124		103		135	11	139	4
Swimming and sports halls	110		163		168		178		146		128		88		178	39	153	15
Churches, chapels	149		150		178		121		114		121		..		133		144	12
Theatre, concert, cinema	131		112		158		149		88		165		122		122	18	130	11
Heated garage	147		117		100		122		84		92		102		157	119	113	16
Other buildings	117		142		127		125		139		130		219		152	21	132	12
All buildings	139	5	135	5	137	5	134	5	118	7	118	8	105	10	139	8	131	2

Table 11. Average use of energy for heating and hot water per m² of total heated area for one- and two-dwelling buildings in 2007 by size of non-residential floor area and year of completion, kWh per m². (Swedish Energy Agency, 2009)

Area (m ²)	-1940	±	1941-1960	±	1961-1970	±	1971-1980	±	1981-1990	±	1991-2000	±	2001-	±	All	±
0	195	4	196	6	168	5	148	3	145	3	136	4	116	4	170	2
1 – 60	166	5	148	6	138	5	131	4	127	3	128	5	103	4	142	2
61 –	136	6	119	5	114	5	103	4	111	4	106	11	87	5	117	3
All	178	3	156	4	140	3	134	2	136	2	130	3	107	2	150	1

Table 12. Average energy use in multi-dwelling buildings in 2008, by type of building year, ownership dimensions, temperature zone and by type of heating [litres resp. kWh per m²] (Swedish Energy Agency, 2009a)

Heating sources	Oil combustion (litres/m²)		District heating (kWh/m²)		Electricity based heating (kWh/m²)		Natural gas (kWh/m²)		Other heating sources (kWh/m²)		All (kWh/m²)	
Year of construction		±		±		±		±		±		±
–1940	18.1	3.6	155	6	93	17	165		132	11	149	5
1941–1960	18.3	3.4	158	4	139	22			132	19	155	4
1961–1970	13.2	3.6	146	6	136	16			128	12	144	6
1971–1980	20.2		146	7	137	18			162	40	144	7
1981–1990	15.0		137	11	117	11			137	47	135	12
1991–2000	..		126	11	117	18	136		122	17	126	9
2001–	–		122	12					90	32	116	13
Data is missing	19.8	5.2	144	6	153	24	175		141	18	145	6
Ownership category												
Public	23.1	8.5	139	38	167	49			196		157	31
Private	16.9	2.2	151	5	111	11			136	9	147	4
Tenants	21.1	6.7	143	4	117	19	167	42	124	13	140	4
Public spaces	16.5	4.8	150	4	140	13	164	68	142	24	150	4
Size												
– 500 m²	18.3	3.0	150	5	120	9	122	9	209	108	140	4
501– 1 000 m²	19.0	2.6	162	4	127	12	133	13	129	28	155	4
1 001– 2 000 m²	15.3	4.9	154	4	119	22	133	16	179		151	4
2 001– 3 000 m²	..		146	5			150	18			146	5
3 001– m²	–		138	5			133	21			137	5
Weather zone												
Weather zone 1	..		171	11	162	25	–		124	17	165	9
Weather zone 2	17.3	5.3	153	6	136	11	–		150	19	150	7
Weather zone 3	19.6	2.5	148	3	119	13	199		136	12	146	3
Weather zone 4	12.8	2.7	143	5	107	15	157	32	121	11	139	4
All	17.7	2.0	148	3	123	8	166	32	133	8	145	2

Benchmarking metabolic impacts for Stockholm Royal Seaport

Table 13. Benchmarking for the Stockholm Royal Seaport developments in the Hjorthagen area

	Indicator	City of Stockholm	Stockholm Royal Seaport (Hjorthagen)	Benchmark data EU	Impact
Energy buildings	Residential energy per m ² floor space	196 kWh/m ² /year	55 kWh/m ² /year	n.a.	++
	Residential energy consumption <i>per capita</i> (kWh/cap/year)	8,588 kWh/cap/year	2,668 kWh/cap/year	n.a.	++
	Electricity consumption <i>per capita</i> (kWh/cap/day)	21.36 kWh/cap/day	2.5 kWh/cap/day	n.a.	++
	District heating consumption <i>per capita</i> (kWh/cap/day)	24.29 kWh/cap/day	6.3 kWh/cap/day	n.a.	++
	Oil consumption for heating (kWh/cap/day)	5.34 kWh/cap/day	0 kWh/cap/day	n.a.	++
	Energy consumption per sector (Final)	Buildings 65% Transport 28% Industry 7%	Buildings 37.7%, Transport 62.3%;	n.a.	+
	% of renewable sources of energy in the total energy consumption	48% (The county)	Goals are not set but it is forecasted to be significantly higher relative to the City.	15.60%	++
Energy transports	Percentage of journeys to work by car	47% (The county)	Approximately 38%	EU15-57.8; EU27 - 55.2%	++
	Modal split of passenger transport	(The county) Pedestrian 15% Bicycles 6% Car 47% Public 30% Other 2% Figures correspond to the county.	Pedestrian 16% Bicycles 10%; Car 38% Public 35% Other 2%. (No official figures)	n.a.	+
	Length public transport	Bus 34,089 km Tram and light train 587 km Commuting train 587 km Subway 655	The decision on the public transport system has been taken. The accessibility of public transport is a priority and therefore expected to be high relative to the rest of the City.	EU average 94.1 km	++
	Passenger car density <i>per capita</i>	0.364 cars/cap	0.185 cars/cap	EU15 - 0.4256; EU27- 0.4109	++
	Number of parking places <i>per capita</i>	n.a	0.185 cars/cap	n.a.	+
Land use	Population density	42.9 cap/ha	127 cap/ha	EU average 113.1 cap/km ²	++

	Land use mix index population+jobs /km ²	7,211.3	16,736	n.a.	++
	Number of households	357,059 (year 1990)	6,385 (5,000 in new developments)	EU15-19894022; EU27-18037792	n.a
	Residential floor space <i>per capita</i>	38.3 m ² /cap	49.6 m ² /cap	n.a.	+
	Density of green public areas (green and open areas)	122.2 m ² /cap	23 m ² /cap	41.2 m ² /cap	-- The scale is not appropriated.
	Urbanised (sealed) area <i>per capita</i>	110.9 m ² /cap	58.6 m ² /cap	n.a.	+
	% of sealed surfaces	47.60%	71.90%	n.a.	+
	% of sealed surfaces (inclusive open areas)	73.52%	85.5%	n.a.	+
Water	Water consumption <i>per capita</i> (Residential and corporative. Losses not included)	244 l/cap/day	111 l/cap/day	EU15- 82.71 m ³ /cap/year; Eu27-68.46 m ³ /cap/year	++
	Water consumption as a function of built-up area -l/m ² /day	2.45 l/m ² /day	1.71 l/m ² /day	n.a.	+
	Water consumption by residential sector	200 l/cap/day	100 l/cap/day	n.a.	+
	Wastewater production <i>per capita</i>	270	111	n.a.	+
	Population connected to WWTP	100%	100%	EU-94.6%; EU27-93.8%	0+
The criteria consisted of comparing the planning proposal to both its urban context and to a standard urban context value: ++ The intervention area has a better performance than the benchmark data. +- The intervention area has a better performance than the benchmark data. -+ The intervention area has a worse performance than the benchmark data. -- The intervention area has a worse performance than the benchmark data. + The intervention area has a better performance for one and there is no data available to compare it with the remaining - The intervention area has a worse performance for one and there is no data available to compare it with the remaining 0+ The intervention area has the same performance criterion, and a better performance than the remaining criterion. 0- The intervention area has the same performance as one and a worse performance than the remaining criterion.					

Annex II

Newcastle Great Park

Standard calculations on the consumption of land, heat and electricity (Newcastle MIA)

Table 14. Description of layout

Description of layout	Area
Total area of the NGP planning proposal (based on the master plan)	4,034,894m ²
Total area of the NGP planning proposal included in this assessment	2,737,568m ²
Excluded cells (un-developed with no detailed plans)	784,922m ²
Excluded strategic green space (surrounding excluded cells)	512,404m ²
Street System (Roads, driveways, parking spaces)	
Main arterial routes (outside development cells)	c.a. 212,448m ²
B: Business park	c.a. 4,865m ²
B: park and ride	c.a. 14,552m ²
C: Business park	c.a. 9,187m ²
F: East Village / First School	c.a. 14,111m ²
F: Brunton Green	c.a. 20,155m ²
F: Phase 3	c.a. 26,554m ²
F: Commercial Quarter	c.a. 51,569m ²
G: Greenside	c.a. 76,200m ²
H: Warkworth Woods	c.a. 19,158m ²
I: Melbury	c.a. 86,500m ²
Roads Total:	c.a. 533,780m ²
Green areas	
Strategic green space	c.a. 1 320,260m ²
Local green space	c.a. 92,328m ²
Residential building coverage (properties)	c.a. 451,931m ²
Commerce and public service building coverage (properties)	c.a. 131,187m ²
Total gross building area (residential + commerce + public facilities)	c.a. 583,118m ²
<i>Compiled from official planning documents (NGP Master Plan: Newcastle City Council, 2006); Firth, personal communication, 2010; Jordan, personal communication, 2010)</i>	

Table 15. Characterisation of the infrastructures' consumption of space in the planning proposal

Land use / development cell	Number	Total Area	Property Area	Plot
Public Facilities				
F: Brunton School	c.a. 10	c.a. 17,813m ²	c.a. 16,234m ²	c.a. 1,712m ²
F: Community Centre	c.a. 5 – 15			c.a. 900m ²
F: Hotel, hospital, clinic, leisure centre,	?	c.a. 46,778m ²	c.a. 36,429m ²	c.a. 12,445m ²
F: Care home, flex community space, extra care home, primary care home	?	Part of Commercial Quarter	6 254m ²	6,254m ²
Sub-total (public facilities)	?	c.a. 64,591m ²	58,917m ²	21,311m ²
Economic Areas				
B: Business park	c.a. 1,600	148,687m ²	56,408m ²	10,819m ²
C: Business park	c.a. 300	221,723m ²	10,173m ²	3 253m ²
F: Commercial Quarter	?	c.a. 60,285m ²	5,689m ²	5,689m ²

Sub-total (commerce jobs)	2,500 – 3,000	c.a. 430,695m ²	72,270m ²	19,761m ²
Residential Areas				
F: Commercial Quarter (mixed use “affordable” residential)	125	Part of Commercial Quarter	4,328m ²	4,328m ²
F: East Village	82	35,931m ²	c.a. 20,422m ²	6,939m ²
F: Brunton	284	90,036m ²	c.a. 66,247m ²	21,307m ²
F: Phase 3	360	112,928m ²	c.a. 83,975m ²	c.a. 27,008m ²
G: Greenside	320	189,454m ²	103,488m ²	28,800m ²
H: Warkworth Woods	175	57,101m ²	36,230m ²	15,050m ²
I: Melbury	500	229,658m ²	137,241m ²	50,373m ²
Sub-total (residential dwellings)	1 846	715,108m ²	c.a. 451,931m ²	c.a.153,805m ²
Total (all buildings)	N/A	c.a. 1,210,394m ²	c.a. 583,118m ²	c.a.194,877m ²
Parking		Green Space		
Non-residential parking		Strategic green space		c.a.1 320,260m ²
B: park and ride	546	Local green space		
B: Sage business park	1 206	B: Business park		c.a. 59,792m ²
C: Business park	229	C: Business park		c.a. 6,603 m ²
F: East Village road spaces	c.a. 37	F:Commercial Quarter		c.a. 2,794m ²
F: Brunton Green road spaces	c.a. 63	F: East Village		c.a. 4,556m ²
F: Phase 3	c.a. 80	F: Brunton		c.a. 2,482m ²
F: Commercial Quarter	c.a. 866	F: Phase 3		c.a. 2,399m ²
Private parking		G: Greenside		c.a. 6,072m ²
F: Commercial Quarter	c.a.177 (1.5/dw)	H: Warkworth Woods		c.a. 1,713m ²
F: East Village	c.a. 123 (1.5/dw)	I: Melbury		c.a. 5,917m ²
F: Brunton	c.a. 426 (1.5/dw)	Sub-total (local green space)		c.a. 92,328m ²
F: Phase 3	c.a. 540 (1.5/dw)			
G: Greenside	c.a. 480 (1.5/dw)			
H: Warkworth Woods	c.a. 265 (1.5/dw)			
I: Melbury	c.a. 750 (1.5/dw)			
Total (public and private parking)	c.a. 5 788	Total (green space)		c.a. 1,412 588m ²
Compiled from official planning documents (NGP Master Plan: Newcastle City Council, 2006); Firth, personal communication, 2010; Jordan, personal communication, 2010)				

Table 16. Land cover types and estimated sealed surfaces for the planning proposal

	N ^a Units (blocks)	Area (m ²)	Area (ha)	% of Area	Sealed Surfaces %	Sealed Surfaces (m ²)	Sealed Surfaces (ha)
Commercial / Office (potentially mixed use)	10	114,953	11.50	4.54%	85%	97,710	9.77
Industrial	0	0	0	0	n/a	n/a	n/a
Isolated Public Services	12	16,234	1.62	0.64%	65%	10,552	1.06
Single Family Homes	c.a. 1,077	290,861	29.09	11.50%	60%	174,517	17.45
Medium Density Residential	c.a. 644	156,742	15.67	6.20%	80%	125,394	12.39
High Density Residential	125	4,328	0.43	0.17%	85%	3,678	0.37
Transport Areas	n/a	533,780	53.38	21.10%	100%	533,780	53.38
Property Shells	n/a	0	0	0	n/a	n/a	n/a
Leisure or open space (green space)	n/a	1,412,588	141.26	55.84%	0%	0	0
Unclassified	0	0	0	0	n/a	n/a	n/a
Total		2,529,486	252.95	100%	37.38%	945 631	94.56

*Note that this area only represents the areas in cells B, C and the Commercial Quarter where building is completed or detailed plans have been made. As such it does not include the approximately 208 082m² of land in cells B and C that will be developed based on future demand.
Please note that with the exception of the Commercial / Office typology, building covered surfaces are considered in terms of estimated property areas.

Table 17. Variables for standard energy consumption (average floor space: Jordan, personal communication, 2010; estimated energy consumption via Energy Performance Certificate averages: Ewles, personal communication, 2011).

Development Cell	No. of dwellings	Floor space m ²	Average gas demand kWh/m ² /year	Average electricity demand kWh/m ² /year	Average total energy demand kWh/m ² /year
F: East Village	82	9,405	99	23	122
F: Brunton	284	32,319	99	23	122
F: Phase 3	360	40,968	99	23	122
F: Commercial Quarter	125	10,499	99	23	122
G: Greenside	320	59,200	99	23	122
H: Warkworth Woods	175	21,053	99	23	122
I: Melbury	500	84,250	99	23	122

Table 18. Estimated average energy consumption of the residential development cells in NGP

Development Cell	Residential heat kWh/year	Residential electricity kWh/year	Residential Emissions Tonnes of CO ² /year	Residential Energy Cost £/year	Total energy consumption kWh/year
F: East Village	931,095	216,315	186	35,721	1,147,410
F: Brunton	3,199,581	743,337	640	122,750	3,942,918
F: Phase 3	4,055,832	942,264	812	155,599	4,998,096
F: Commercial Qtr.	1,039,401	241,477	208	39,876	1,280,878
G: Greenside	5,860,800	1,361,600	1,173	224,846	7,222,400
H: Warkworth Woods	2,084,247	484,219	417	79,961	2,568,466
I: Melbury	8,340,750	1,937,750	1,670	319,987	10,278,500
Total	25,511,706	5,926,962	5,107	978,740	31,438,668

Energy Performance Certificate for Newcastle Great Park

Energy Performance Certificate		SAP © Crown copyright 2005																																																													
5 Thrunton Walk Newcastle Great Park NEWCASTLE UPON TYNE NE13 9BB		Dwelling type: Detached house Date of assessment: 17 February 2010 Date of certificate: 17 February 2010 Reference number: 8280-6732-7800-7273-2996 Type of assessment: SAP, new dwelling Total floor area: 178 m ²																																																													
This home's performance is rated in terms of the energy use per square metre of floor area, energy efficiency based on fuel costs and environmental impact based on carbon dioxide (CO ₂) emissions.																																																															
Energy Efficiency Rating		Environmental Impact (CO₂) Rating																																																													
<table border="1"> <thead> <tr> <th></th> <th>Current</th> <th>Potential</th> </tr> </thead> <tbody> <tr> <td>Very energy efficient - lower running costs</td> <td></td> <td></td> </tr> <tr> <td>(92 plus) A</td> <td></td> <td></td> </tr> <tr> <td>(81 - 91) B</td> <td>81</td> <td>82</td> </tr> <tr> <td>(69 - 80) C</td> <td></td> <td></td> </tr> <tr> <td>(55 - 68) D</td> <td></td> <td></td> </tr> <tr> <td>(39 - 54) E</td> <td></td> <td></td> </tr> <tr> <td>(21 - 38) F</td> <td></td> <td></td> </tr> <tr> <td>(1 - 20) G</td> <td></td> <td></td> </tr> <tr> <td>Not energy efficient - higher running costs</td> <td></td> <td></td> </tr> </tbody> </table>			Current	Potential	Very energy efficient - lower running costs			(92 plus) A			(81 - 91) B	81	82	(69 - 80) C			(55 - 68) D			(39 - 54) E			(21 - 38) F			(1 - 20) G			Not energy efficient - higher running costs			<table border="1"> <thead> <tr> <th></th> <th>Current</th> <th>Potential</th> </tr> </thead> <tbody> <tr> <td>Very environmentally friendly - lower CO₂ emissions</td> <td></td> <td></td> </tr> <tr> <td>(92 plus) A</td> <td></td> <td></td> </tr> <tr> <td>(81 - 91) B</td> <td></td> <td></td> </tr> <tr> <td>(69 - 80) C</td> <td>80</td> <td>81</td> </tr> <tr> <td>(55 - 68) D</td> <td></td> <td></td> </tr> <tr> <td>(39 - 54) E</td> <td></td> <td></td> </tr> <tr> <td>(21 - 38) F</td> <td></td> <td></td> </tr> <tr> <td>(1 - 20) G</td> <td></td> <td></td> </tr> <tr> <td>Not environmentally friendly - higher CO₂ emissions</td> <td></td> <td></td> </tr> </tbody> </table>			Current	Potential	Very environmentally friendly - lower CO ₂ emissions			(92 plus) A			(81 - 91) B			(69 - 80) C	80	81	(55 - 68) D			(39 - 54) E			(21 - 38) F			(1 - 20) G			Not environmentally friendly - higher CO ₂ emissions		
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England & Wales EU Directive 2002/91/EC		England & Wales EU Directive 2002/91/EC																																																													
The energy efficiency rating is a measure of the overall efficiency of a home. The higher the rating the more energy efficient the home is and the lower the fuel bills are likely to be.		The environmental impact rating is a measure of a home's impact on the environment in terms of carbon dioxide (CO ₂) emissions. The higher the rating the less impact it has on the environment.																																																													
Estimated energy use, carbon dioxide (CO₂) emissions and fuel costs of this home																																																															
	Current	Potential																																																													
Energy use	115 kWh/m ² per year	109 kWh/m ² per year																																																													
Carbon dioxide emissions	3.4 tonnes per year	3.2 tonnes per year																																																													
Lighting	£148 per year	£91 per year																																																													
Heating	£424 per year	£432 per year																																																													
Hot water	£146 per year	£146 per year																																																													
Based on standardised assumptions about occupancy, heating patterns and geographical location, the above table provides an indication of how much it will cost to provide lighting, heating and hot water to this home. The fuel costs only take into account the cost of fuel and not any associated service, maintenance or safety inspection. This certificate has been provided for comparative purposes only and enables one home to be compared with another. Always check the date the certificate was issued, because fuel prices can increase over time and energy saving recommendations will evolve.																																																															
To see how this home can achieve its potential rating please see the recommended measures.																																																															
 Remember to look for the energy saving recommended logo when buying energy-efficient products. It's a quick and easy way to identify the most energy-efficient products on the market. For advice on how to take action and to find out about offers available to help make your home more energy efficient, call 0800 512 012 or visit www.energysavingtrust.org.uk																																																															

Trip generation and the distribution model for the case study

The traffic model, first introduced in stage 3, has notable shortcomings that limit its ability to meet the needs of this assessment. First, the model only covers the road network directly surrounding the intervention area. Therefore, it does not assess the impact (number of trips and distribution) of the intervention area on car trips throughout the study area. Likewise, we cannot predict potentially unknown, secondary impacts on transport links and nodes that are not directly proximate to the development. Second, it does not infer trip origins and destinations. As such, we are unable to estimate average trip length (and therefore, average fuel consumption). Third, the modelling only provides an estimation of additional peak hour trips along the A1 motorway. While this will be the main entry and exit to the development (upwards of 70% of trips will move through the North Brunton/A1 Interchange) it does not factor in trips for the remaining percentage, nor does it account for internal trips within the development area. Fourth, the model uses 2008 as a base year for calculating trip generation. This means that the development already completed by 2008 (600 homes and the Sage business park in Cell B) is included in the base trip rates and is therefore not counted as increased traffic caused by the development.

The model template provided by *JMP Consultants* was adapted in a step by step process to determine the trip generation and distributional impacts caused by development. In the first step, the model simply predicts the number of peak hour trips that will be produced by the development, then maps the distribution of these trips along the transport network surrounding the A1 motorway. Trip volume is determined by standardised trip rates derived from the 'TRICS 2011(a)v6.7.1' database¹⁴ to derive representative trip rates for the various land use classifications in the intervention area. In some cases these trip

rates were then manually augmented to correspond to locational determinants within the NGP. For example, peak hour trip rates per household were increased proportionate to the increased level of car ownership predicted for the homes in NGP. Similarly, trip rates for retail, food shops, primary school, nursery, etc., were reduced to accommodate the fact that internal trips in the intervention area are not included in the modelling. As a result, Table 19 shows that peak hour trips rates are multiplied by parameters on the size of each land use classification to determine the total number of trips generated by the developed area.

On the one hand, these totals are used as inputs for the next stage of the model (see below), but they are also useful as totals that can be multiplied by regional averages on average trip length (projected to be 11.8 km in 2031¹⁵) and fuel consumption to determine other sets of transport impacts used in this study (See STAGE 3, energy impacts from transport).

In the second step, trip generation results Table 19 are complimented by the distribution analysis Table 20, which uses an automatic number plate recognition (ANPR) survey (completed in March 2010) to determine the distribution pattern of peak hour trips to and from the main entry/exit point to the development area (Route 1). In turn, this allows for step three, where the distribution analysis at Route 1 is used to map trip generation along the A1 Corridor. Thus, the impact of car trips entering and exiting from NGP at Route 1 (the North Brunton Interchange) is illustrated in Figure 21. This accounts for 4 331 (75%) of the 5 813 daily peak hour trips generated by the development between 2008 and its completion.

¹⁴ TRICS is the UK and Ireland's national system for trip generation analysis. (<http://www.trics.org/>).

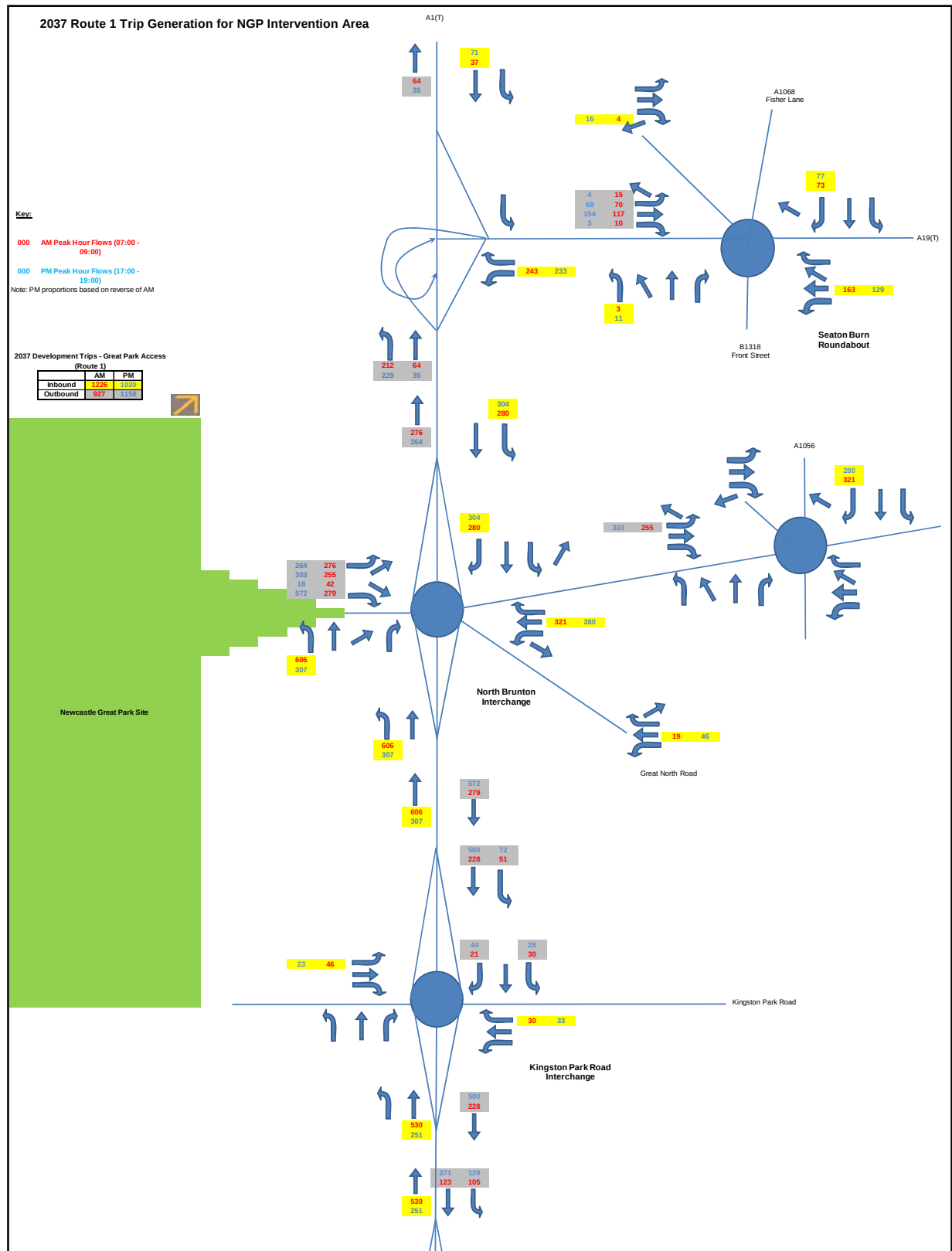
¹⁵ An 11.8 km average trip length is based on findings provided in Table 5.7 in Enchenique *et al.*, 2010 pp. 140. Use of a regional average is justified by the peripheral location of NGP in relation to the city centre and key economic development zones to the south of the River Tyne. This indicates that trip lengths could correspond to averages across the municipality.

Table 19. NGP trip rate worksheet showing individual land uses, size (floor space in m²) of non-residential development and number of dwellings. These are multiplied by the peak hour trip rates to determine peak hour trip rates caused by development in NGP.

Site Ref	Land Use	Size	Dwellings/spaces	Trips RateIn AM	Trips RateOut AM	Trips RateIn PM	Trips RateOut PM	Trips Rate In AM	Trips Out AM	Trips In PM	Trips Out PM
B1 2008 BASE	B1	34000	0	3,35	0,325	0,375	2,425	1139	111	128	825
Housing 2008 BASE	Housing	0	600	0,17	0,87	0,84	0,23	102	522	504	138
B1 2037 COMPLETE	B1	9759	0	3,35	0,325	0,375	2,425	327	32	37	237
Housing 2037 COMPLETE	Housing	0	1246	0,17	0,87	0,84	0,23	212	1084	1047	287
Park and Ride	park and ride	0	546	0,8	0	0	0,8	437	0	0	437
C2 2037 COMPLETE	Hospital	12500	0	0,56	0,15	0,25	0,32	70	19	31	40
C1 2037 COMPLETE	Hotel	6938	0	0,26	0,44	0,47	0,29	18	31	33	20
D1 2037 COMPLETE	Community Centre, Flex Space	18718	0	0,26	0,26	0,43	0,43	49	49	80	80
D2 2037 COMPLETE	Anicallary health clinic	3497	0	1,6085	0,612	1,02	2,281	56	21	36	80
D3 2037 COMPLETE	Nursery/Daycare	1771	0	2,818	1,9775	1,664	2,1605	50	35	29	38
D4 2037 COMPLETE	School (Primary)	1712	0	2,481	1,6285	0,345	0,4265	42	28	6	7
D5 2037 COMPLETE	Leisure	5000	0	2,08	2,08	1,81	2,08	104	104	91	104
A1 2037 COMPLETE	Retail, Food Retail	8726	0	3,29	2,28	6,7	7,29	287	199	585	636
							Total Peak Hour Trips	2893	2233	2605	2929

Table 20. Matrix showing the distribution analysis; where percentages relate to the percentage of trips from one node/link being directed towards the corresponding link/node.

ANPR Analysis		A1 North of Seaton Burn	Great North Road (Holiday Inn)	A1068	A19	Front Street (Seaton Burn)	Great Park	Great North Road (Gosforth)	A1056	Kingston Park Road (West)	Kingston Park Road (East)	Ponteland Road (West)	Woolington Bypass	Ponteland Road (East)	Stamfordham Road (West)	Stamfordham Road (East)	West Road (West)	West Road (East)	South
	C	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
A1 North of Seaton Burn	1	0	0	0	0	0	3%	0	0	6%	0	0	1%	0	0	0	0	0	0
Great North Road (Holiday Inn)	2	0	0	0	0	0	0%	0	0	0%	0	0	0%	0	0	0	0	0	0
A1068	3	0	0	0	0	0	6%	0	0	4%	0	0	0%	0	0	0	0	0	0
A19	4	0	0	0	0	0	13%	0	0	8%	0	0	2%	0	0	0	0	0	0
Front Street (Seaton Burn)	5	0	0	0	0	0	0%	0	0	0%	0	0	0%	0	0	0	0	0	0
Great Park	6	7%	2%	8%	13%	1%	0%	5%	27%	2%	3%	1%	0%	10%	0%	2%	2%	2%	8%
Great North Road (Gosforth)	7	0	0	0	0	0	2%	0	0	3%	0	0	1%	0	0	0	0	0	0
A1056	8	0	0	0	0	0	26%	0	0	9%	0	0	2%	0	0	0	0	0	0
Kingston Park Road (West)	9	4%	0%	3%	5%	1%	4%	0%	10%	1%	50%	0%	0%	8%	0%	2%	1%	2%	9%
Kingston Park Road (East)	10	0	0	0	0	0	2%	0	0	51%	0	0	1%	0	0	0	0	0	0
Ponteland Road (West)	11	0	0	0	0	0	3%	0	0	1%	0	0	1%	0	0	0	0	0	0
Woolington Bypass	12	2%	1%	1%	4%	0%	5%	0%	7%	0%	7%	5%	1%	28%	1%	5%	1%	4%	30%
Ponteland Road (East)	13	0	0	0	0	0	3%	0	0	1%	0	0	49%	0	0	0	0	0	0
Stamfordham Road (West)	14	0	0	0	0	0	3%	0	0	2%	0	0	2%	0	0	0	0	0	0
Stamfordham Road (East)	15	0	0	0	0	0	1%	0	0	1%	0	0	3%	0	0	0	0	0	0
West Road (West)	16	0	0	0	0	0	4%	0	0	0%	0	0	0%	0	0	0	0	0	0
West Road (East)	17	0	0	0	0	0	2%	0	0	1%	0	0	3%	0	0	0	0	0	0
South	18	0	0	0	0	0	23%	0	0	11%	0	0	33%	0	0	0	0	0	0



(Figure continued on next page)

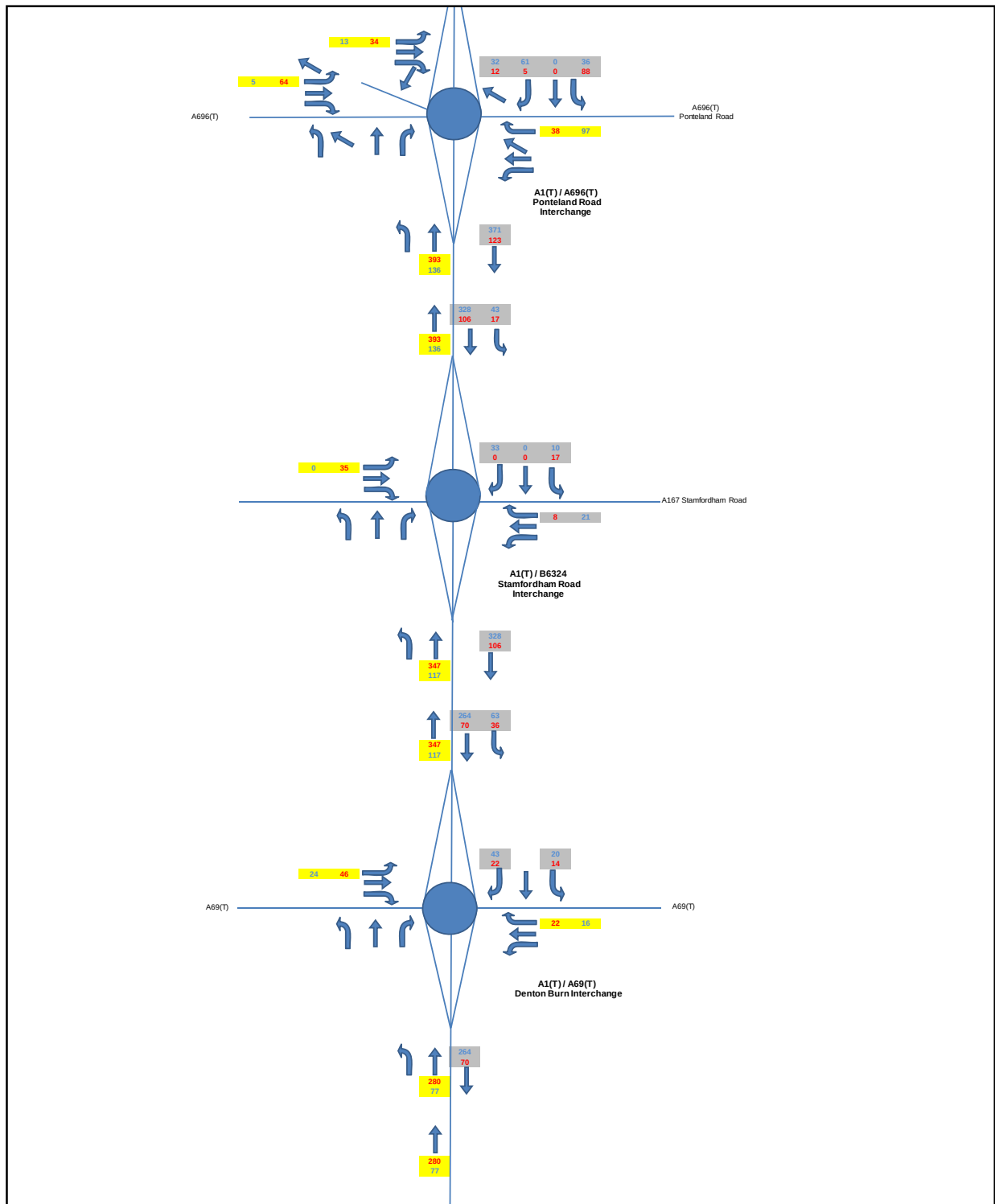
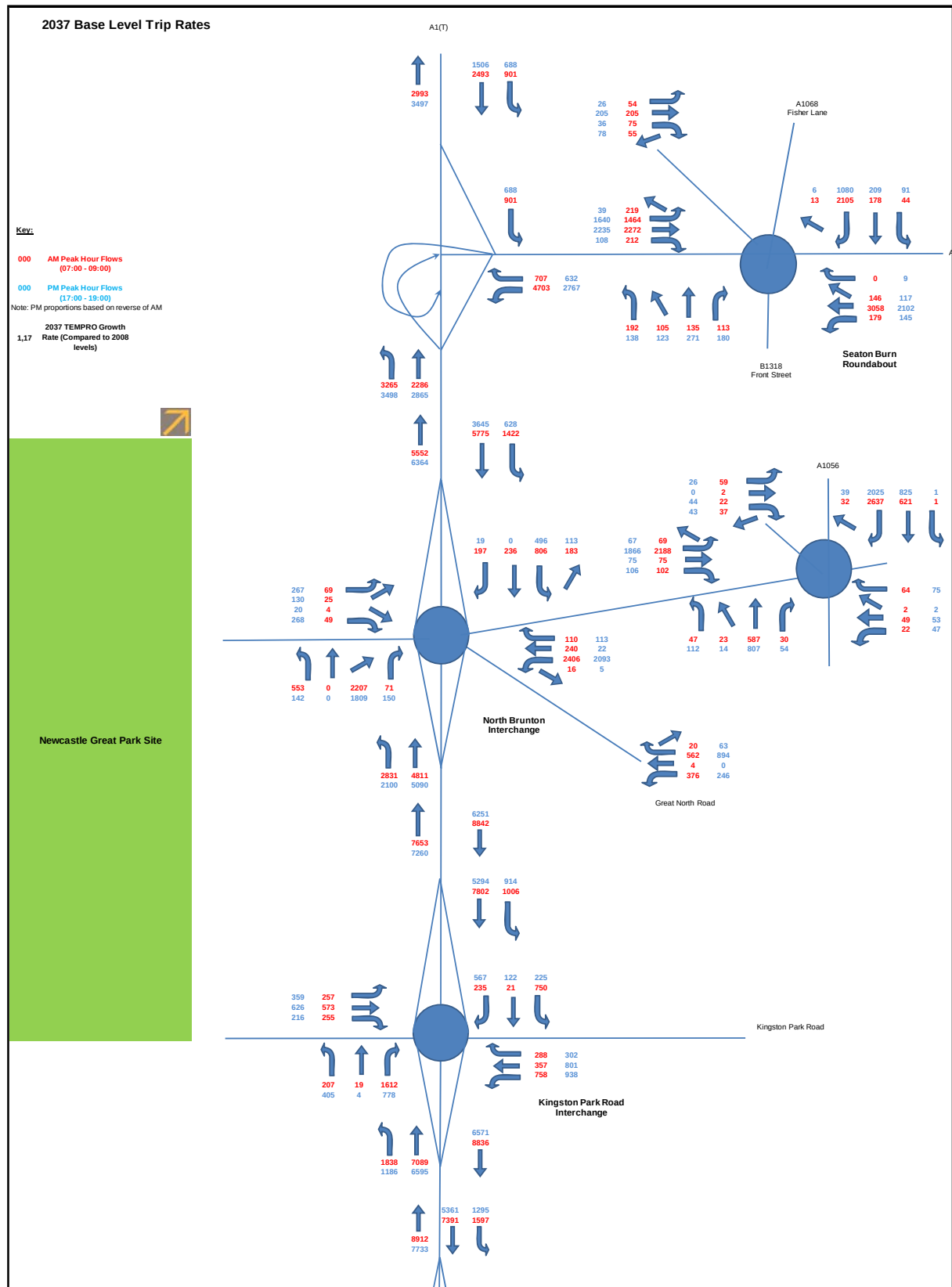


Figure 20. Distribution of predicted Route 1 trip generation resulting from development within NGP



(Figure continued on next page)

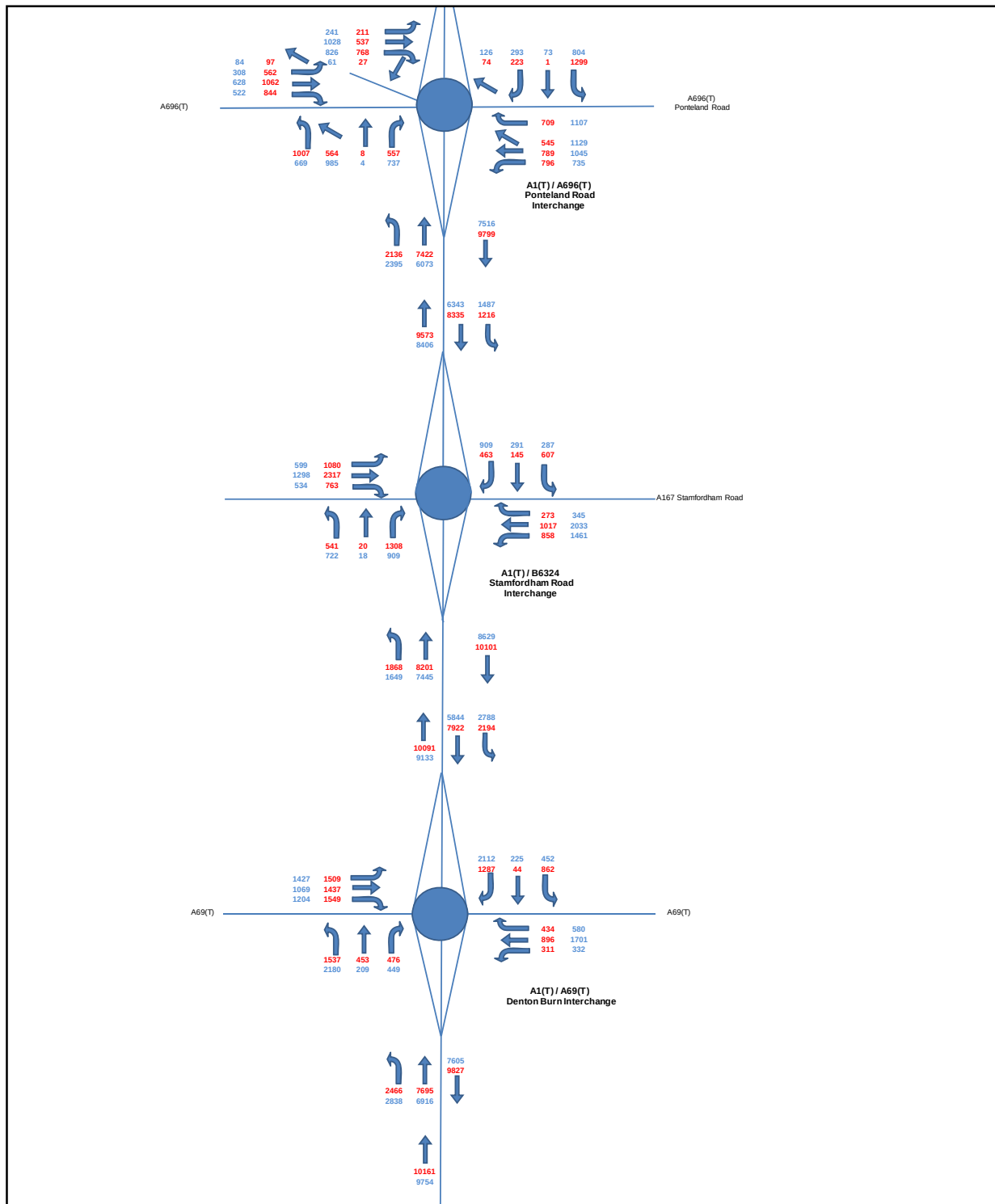
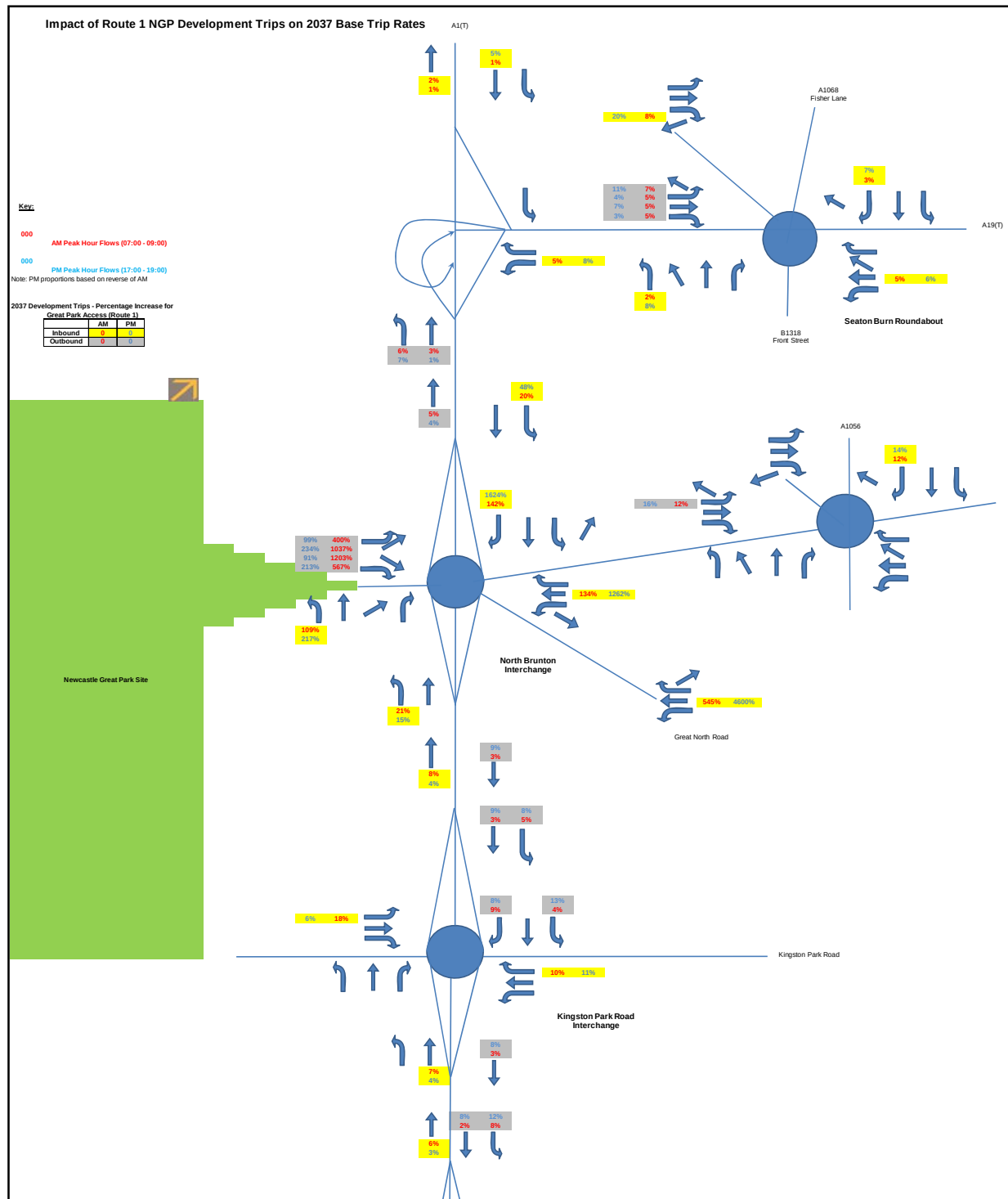


Figure 21. Base level trip rates (according to the 2008 analysis there will be a plus 17% growth rate up to 2037) for the road network surrounding the A1 Corridor between Newcastle Great Park and the inner city



(Figure continued on next page)

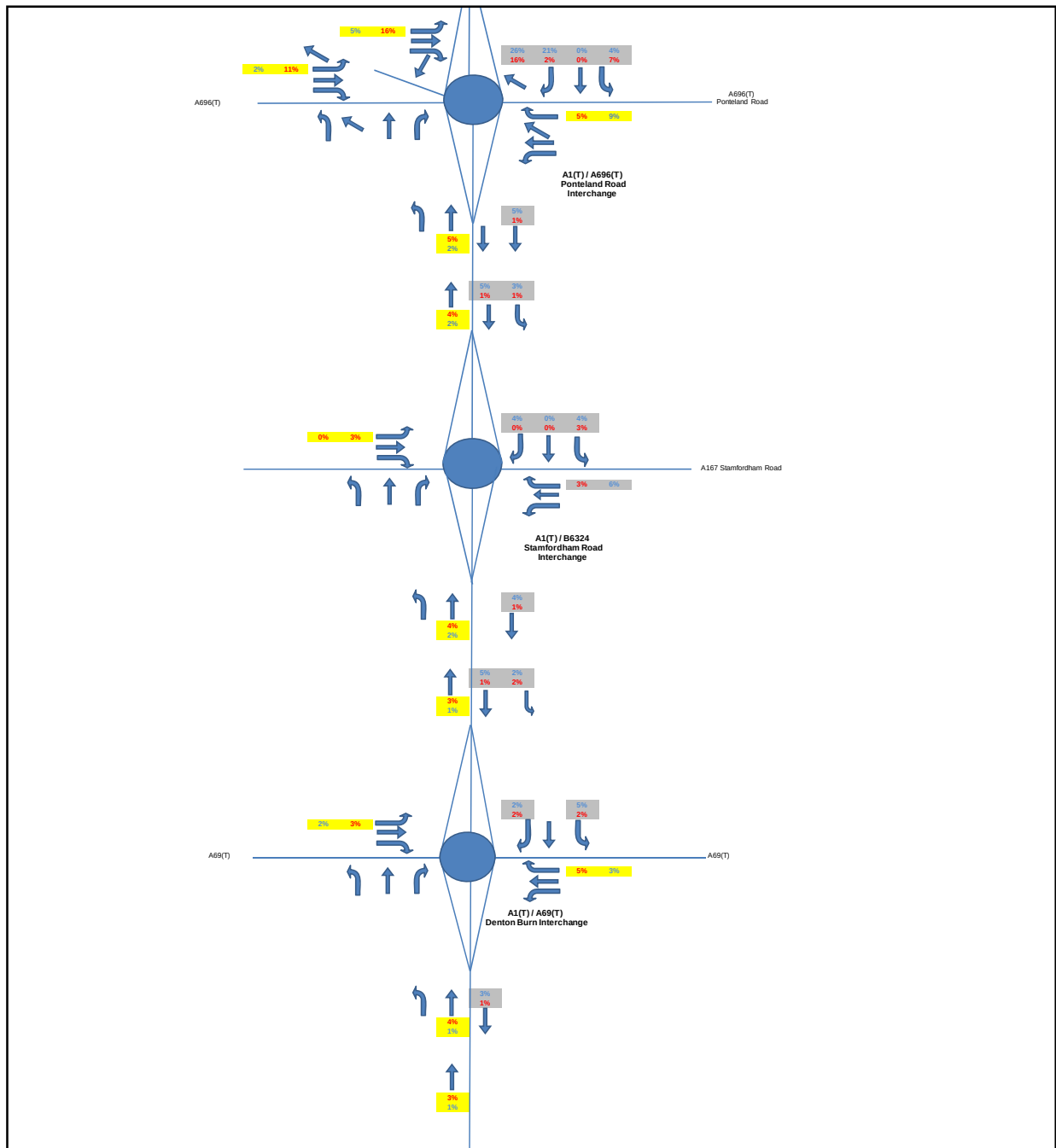


Figure 22. Percentage increase in trips caused by Route 1 entries and exits to NGP on the A1 Corridor and surrounding roads

The 2037 base level of trips shown in Figure 21 was included in the model provided by *JMP Consultants*, and was prepared using traffic data provided by *Count on Us* (undertaken in April 2008 over a 12 hour period between 07:00 and 19:00). A standard regional traffic growth rate of 17% was then applied to account for the increase of traffic between 2008

and 2037. This provides the basis for the last step, where the distribution of predicted Route 1 trip generation resulting from NGP (Figure 20) is divided by the corresponding 2037 base rates (Figure 21) to determine the percentage increase in trips caused by Route 1 entries and exits to NGP. This is shown in Figure 22 above.

2037 Route 1 Trip Generation for NGP Intervention Area

Key:

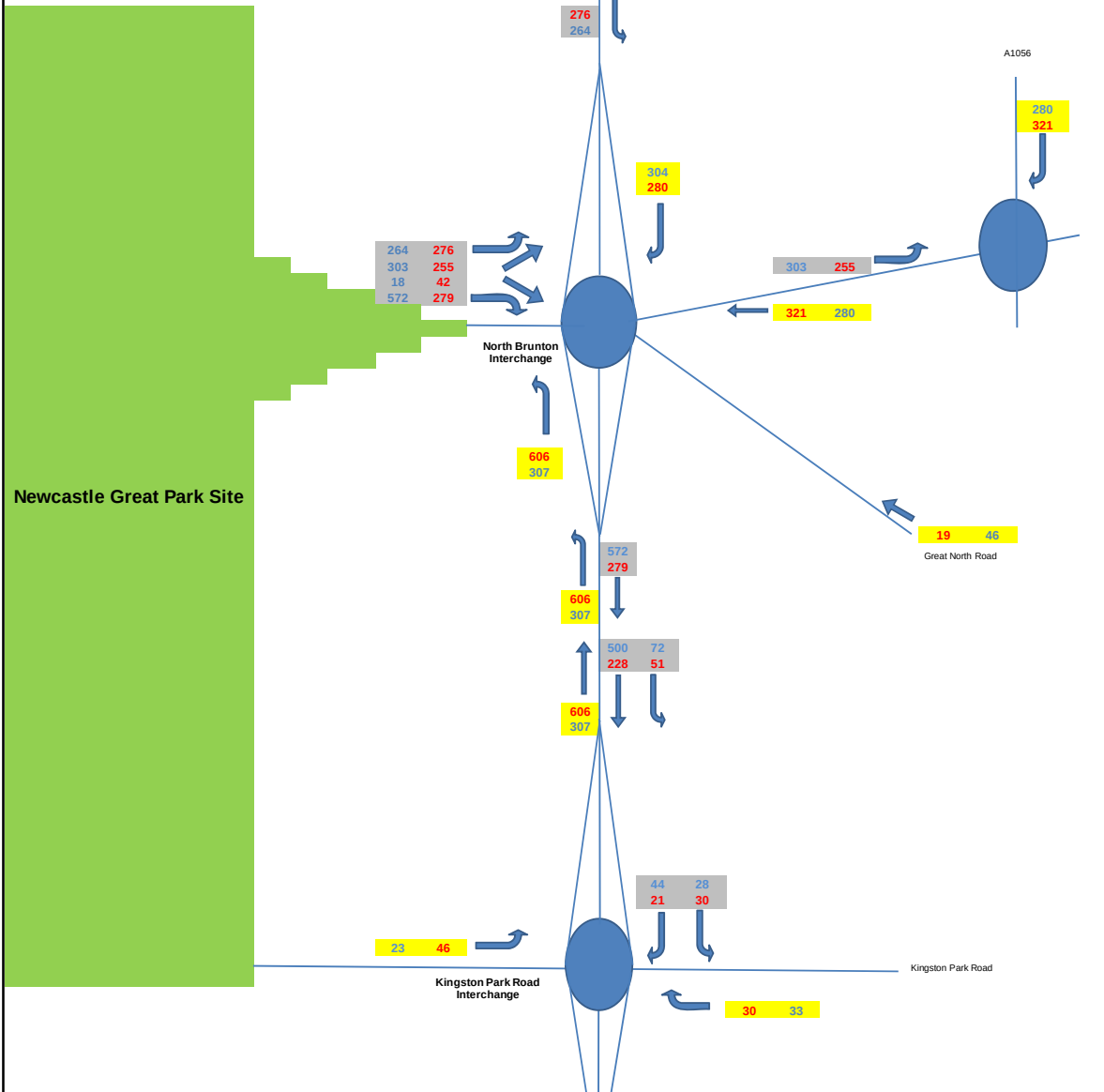
000 AM Peak Hour Flows
(07:00 - 09:00)

000 PM Peak Hour Flows
(17:00 - 19:00)

Note: PM proportions based on reverse of AM

2037 Development Trips - Great Park Access (Route 1 Access)

	AM	PM
Inbound	1226	1020
Outbound	927	1158



(Figure continued on next page)

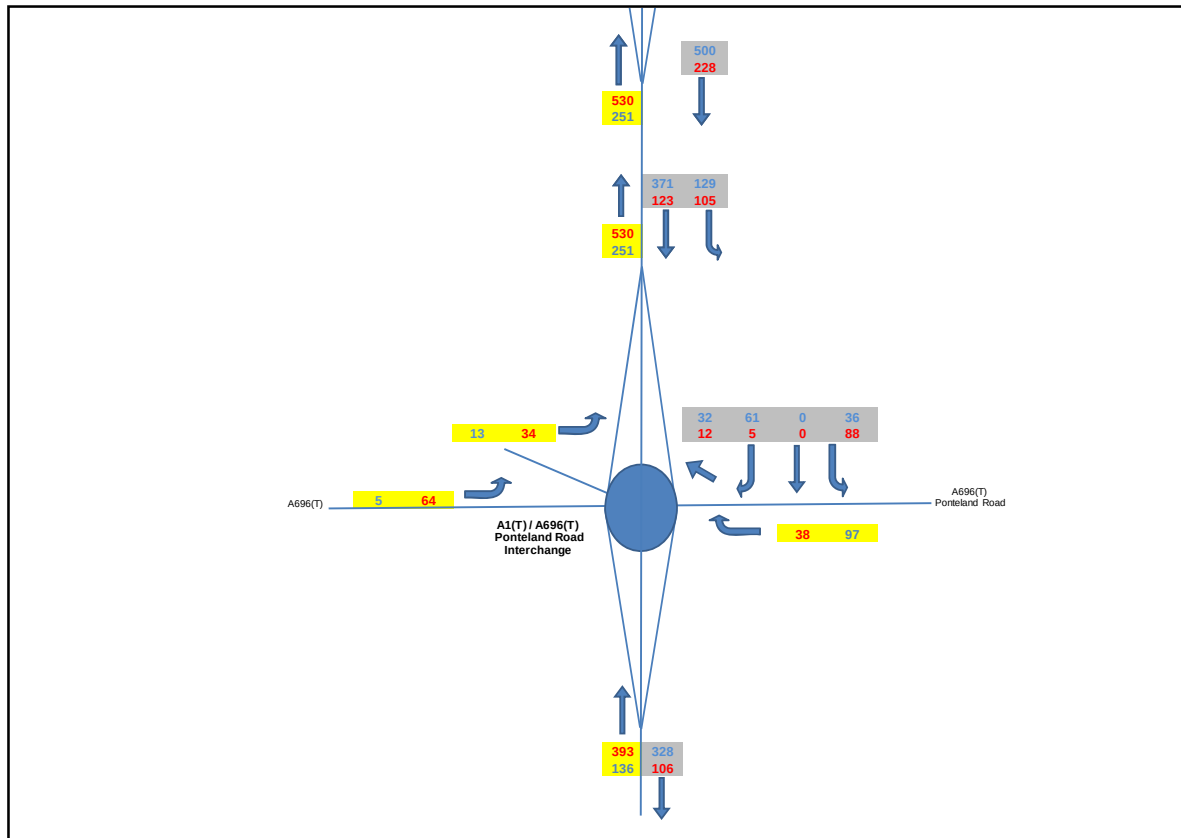


Figure 23. Distribution of predicted Route 1 trip generation resulting from development within NGP

Impact of Route 1 NGP Development Trips on 2037 Base Trip Rates

Key:

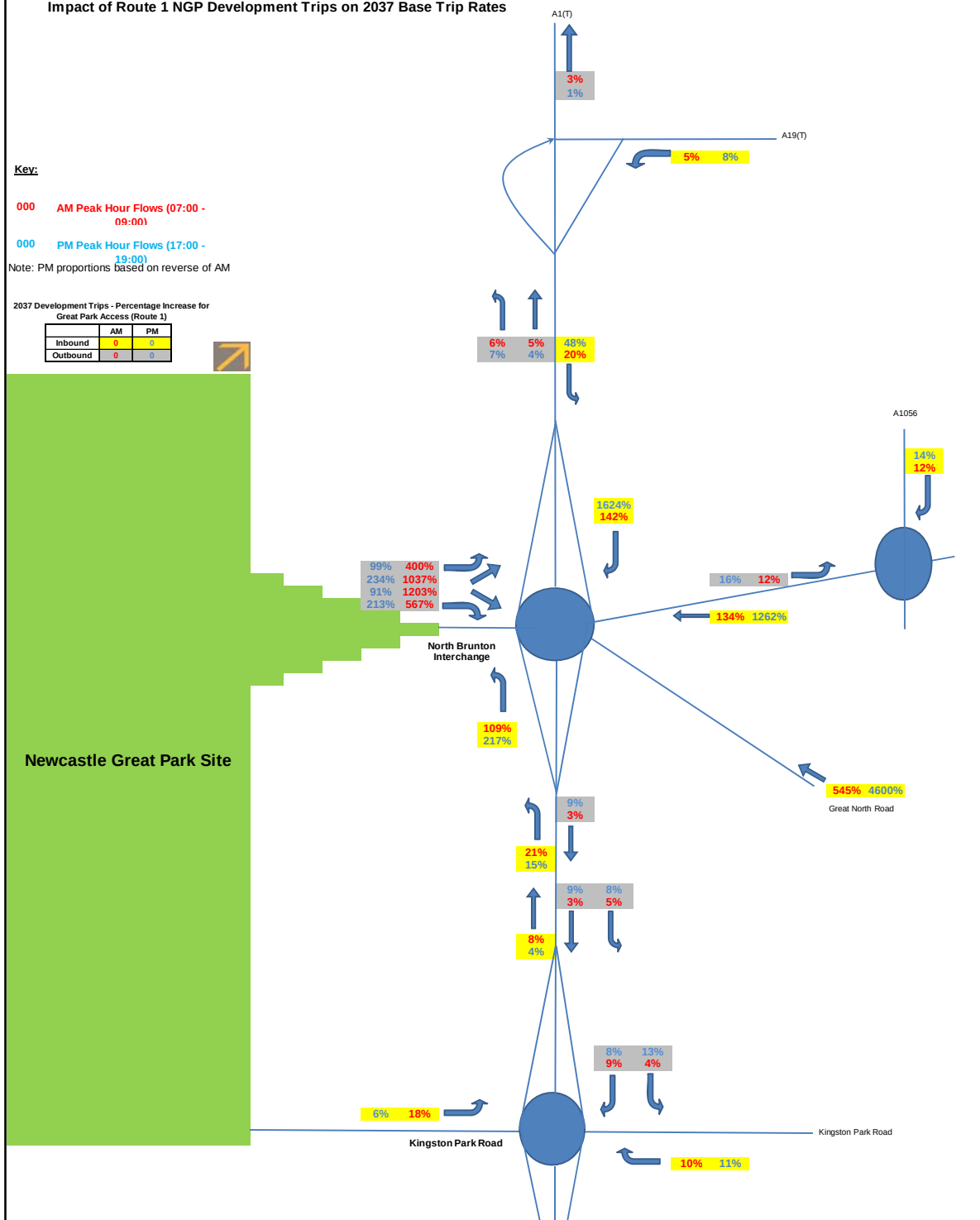
000 AM Peak Hour Flows (07:00 - 09:00)

000 PM Peak Hour Flows (17:00 - 19:00)

Note: PM proportions based on reverse of AM

**2037 Development Trips - Percentage Increase for
Great Park Access (Route 1)**

	AM	PM
Inbound	0	0
Outbound	0	0



(Figure continued on next page)

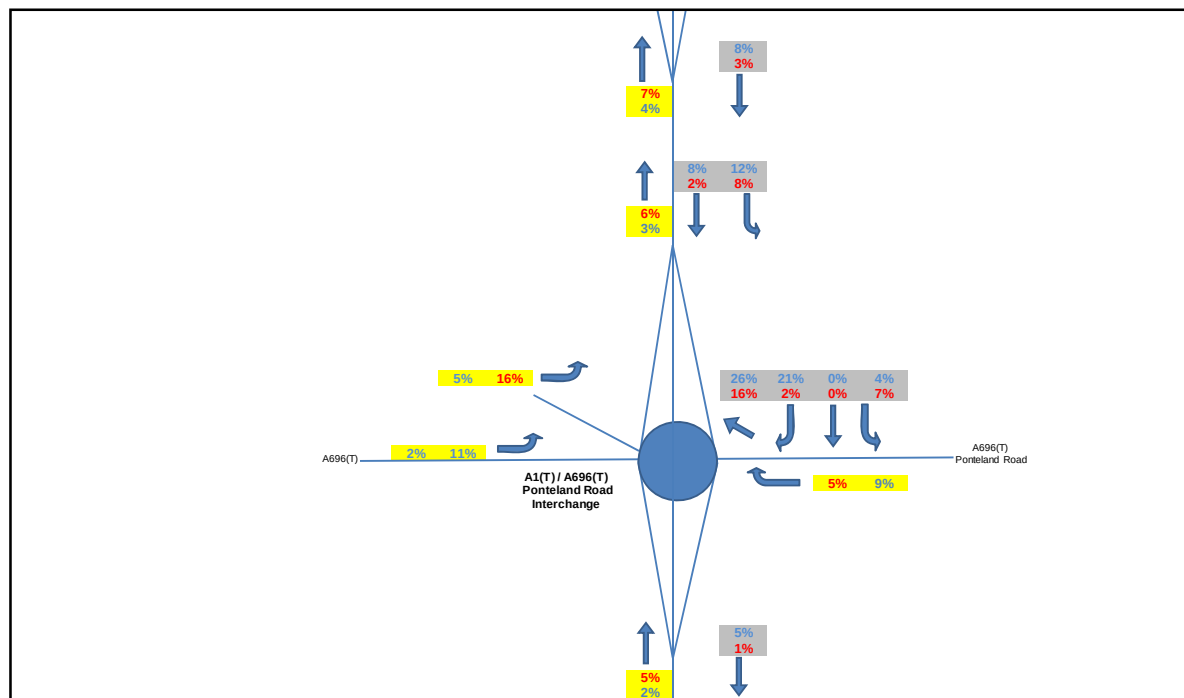


Figure 24. Percentage increase in trips caused by Route 1 entries and exits to NGP on the A1 Corridor and surrounding roads

Benchmarking metabolic impacts for Newcastle Great Park

Table 21. Benchmarking metabolic impacts for Newcastle Great Park

	Indicator	Newcastle Municipality	Newcastle Great Park	Benchmark data	Impact
Energy – buildings (domestic)	Domestic energy consumption <i>per capita</i>	23.36 kWh/cap/day	19.44 kWh/cap/day	EU27 – 15.7 kWh/cap/day	- / n.a.*
	Energy consumption per dwelling (kWh/dwelling/year)	19,273 kWh/dwelling/year	17,031 kWh/cap/day	n.a.	n.a.*
	Domestic electricity consumption <i>per capita</i> (kWh/cap/day)	4.48 kWh/cap/day	3.67 kWh/cap/day	n.a.	n.a.*
	Domestic natural gas consumption <i>per capita</i> (kWh/cap/day)	18.88 kWh/cap/day	15.78 kWh/cap/day	n.a.	n.a.*
	Energy consumption per built-up area	c.a. 112.65 kWh/m ² /yr.	n.a.	n.a.	n.a.*
	Domestic energy consumption per built-up area	c.a. 39.13 kWh/m ² /yr.	33.25 kWh/m ² /yr.		n.a.*
	Energy consumption per sector	Domestic: 38% (space heating 81%, electricity 19%) Transport: 28% Industry: 7%	n.a.	n.a.	n.a.
	% of renewable sources of energy in the total energy consumption	c.a. 1.14% (based on national average of 5% of electricity from renewables, and biomass)	c.a. 1.36% (improvement based on 57 800/year from solar water heating)	EU27- 15.60% UK- 2.43%	=-
Energy - transports	Percentage of journeys to work by car	59% (2001)**	<60%***	EU15-57.8; EU27 - 55.2%	n.a.
	Modal split of passenger transport	Car 50% Bus 21% Rail 1% Metro 3% Walking & Cycling 25%	Car 61% Bus 20% Rail 0% Metro 0% Walking & Cycling 19%	n.a.	n.a.-
	Passenger car density	0.314cars/cap. (2001)	c.a. 0.625cars/cap.	EU15 - 0.4256; EU27- 0.4109	--
	Number of park and ride parking areas per 1000 cap.	5.53	123.02	EU15 - 4.56; EU27 - 4.95	n.a.
Land use	Population density	24.46cap/ha (2008)	16.18cap/ha	EU average 113.1 cap/km ²	--
	Land use mix index population+jobs /km ²	3997 (2008)	2531 - 2714	n.a.	-
	Number of households	122 878 (2009)	1,846	n.a.	n.a

	Residential floor space <i>per capita</i>	n.a.	55.80m ² /cap	n.a.	-
	Density of green public areas (only green areas)	28.06m ² /cap	318.87m ² /cap	41.2 m ² /cap	++
	Urbanised (sealed) area <i>per capita</i>	c.a. 263.60m ² /cap	c.a. 299.09m ² /cap	n.a.	-
	% of sealed surfaces	c.a. 53.36%	c.a. 37.38%	EU (at country level) 8.6%	+ -
Water	Indicator	North East Region	Newcastle Great Park	Benchmark data	Impact
	Water consumption by residential sector (<i>per capita</i>)	158 l/cap/day	c.a. 125 l/cap/day	n.a.	+
	Residential water consumption as a function of built-up area -l/m ² /day	0.725 l/m ² /day	c.a. 0.586l/m ² /day	n.a.	+
	Foul water production <i>per capita</i>	135-180l/cap/day	125l/cap/day	n.a.	+
	Surface storm water management	Single drainage system (surface storm water collection is combined with foul water collection)	Dual drainage system (local surface storm water is collected and stored locally)	n.a.	+
	Population connected to WWTP	100%	100%	EU-94.6%; EU27-93.8%	0+

n.a.: data not available/applicable

*: Judgement of energy consumption levels between the study level and intervention level is not possible due to the lack of high quality data? on domestic electricity and natural gas consumption for Newcastle (See above in Footnote 5)

**Data relates to the Tyne and Wear Urban Region as the study area because of a lack of data at the municipal level.

*** An approximation of the percentage of journeys to work in the completed intervention area is not available. However, the combination of the following factors assumes that it will be higher than the 2001 municipal average:. It is also assumed that rates of car ownership will be twice as high as the municipal average, there is no metro service planned for the intervention area, it has a peripheral location in the municipality and there is a higher assumed number of total trips by car in the modal split
The following criteria were used to assess each of the indicators above. The criteria are based on a comparison of the PPA with the study area context as well as a benchmarked urban context at the national and /or EU level.

++ The intervention area has a better performance for both the case study area and benchmark data.

+ The intervention area has a better performance than the case study area, but a worse performance than the benchmark data.

-+ The intervention area has a worse performance than the case study area, but a better performance than the benchmark data.

-- The intervention area has a worse performance than both the case study area and benchmark data.

+ The intervention area has a better performance for one of the selected comparison criterion, and there is no data available to compare it with the remaining criterion.

- The intervention area has a worse performance for one of the selected comparison criterion, and there is no data available to compare it with the remaining criterion.

=+ The intervention area has the same performance as one of the selected comparison criterion, and a better performance than the remaining criterion.

=- The intervention area has the same performance as one of the selected comparison criterion, and a worse performance than the remaining criterion.

Alternative Development for NGP at Great Park West

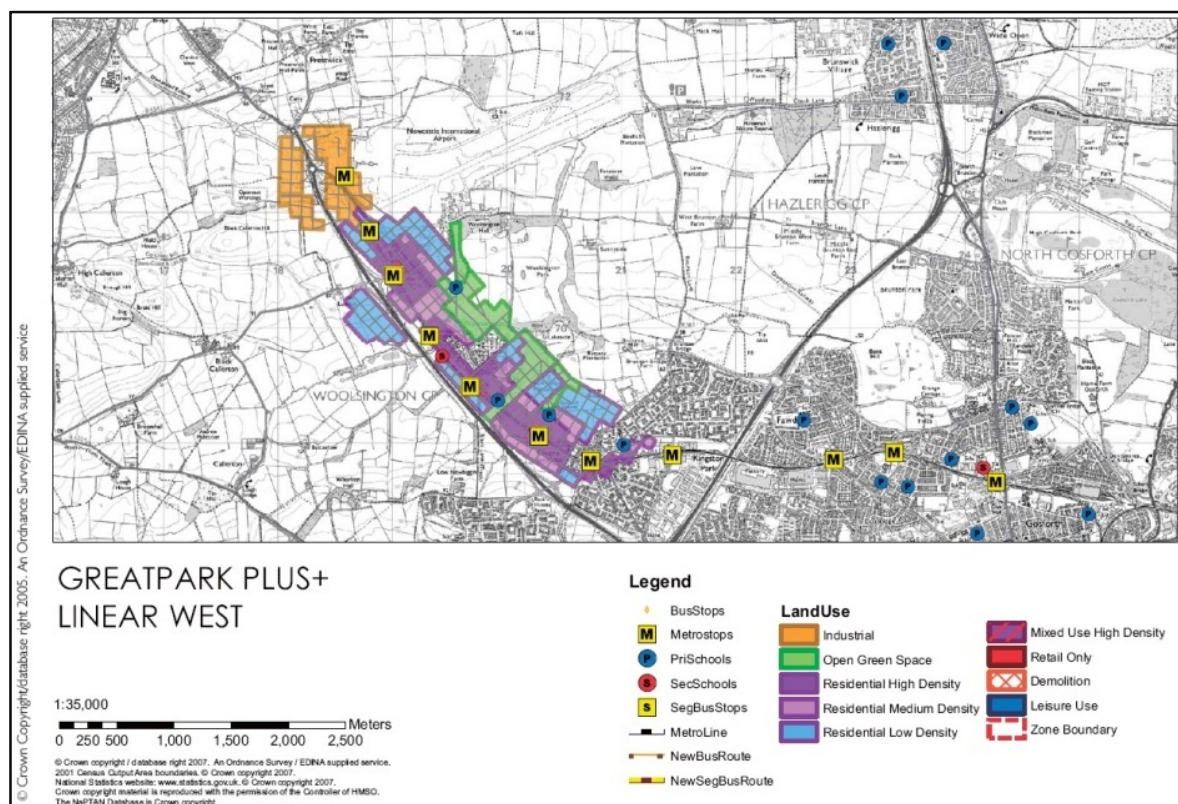


Figure 25. Raster image of the Great Park West alternative as proposed by the SOLUTIONS report. (Rice *et al.*, 2010, pp. 27)



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