Planning for a Resource Efficient Future: Opportunities in Marseille, Newcastle and Stockholm

Introduction

Urban areas are having an unprecedented effect on the environment, resource consumption and land use. As these areas continue to develop, spatially and otherwise, this influence will increase, which could result in significant environmental challenges. Conversely, their increasing prominence means that environmentally sustainable solutions for urban areas have the opportunity to help resolve some of the most demanding global issues that exist today.

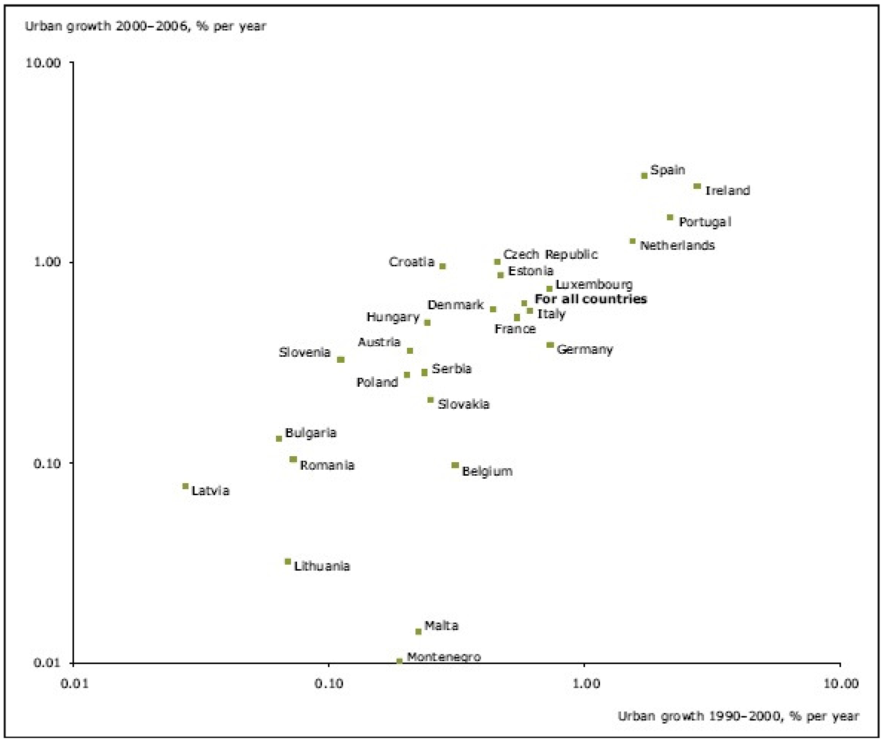
Cities do not exist in a vacuum however. Rather, they need to be considered within their respective development contexts which have been shaped by a range of factors, including geography and planning culture. With this in mind, the European Union funded FP-7 Sustainable Urban Metabolism for Europe (SUME) project evaluates the potentials that different urban areas have to improve resource efficiency between now and 2050 through interventions in terms of land-use and energy consumption from buildings and transport. To accomplish this, two scenarios were developed. One scenario assesses development based on a continued adherence to current planning policies in each urban area, while the other assumes a more resource aware, yet still attainable, outlook that foresees greater resource efficiency in future development patterns. By comparing the long-term BASE and SUME development potentials in selected cities, the variations in land consumption can be identified.

Marseille, Newcastle and Stockholm are three regions across Europe that present interesting outcomes and demonstrate the variation in challenges and opportunities that exist in different urban agglomerations. By comparing current spatial patterns with two long-term scenarios, it is possible to evaluate how population development and changes in the urban fabric will affect resource consumption and influence the physical transformation of these urban areas. In doing so, it is also possible to assess how different planning policies can influence resource efficiency in each of the scenario cities. This allows for the identification of spatially relevant factors in the respective urban regions, highlights key differences between the scenarios, and offers the possibility to compare potentials between urban regions. In turn, this provides the basis for region-specific development strategies that promote land use and resource optimization. Finally, the results highlight efforts that Stockholm, Marseille and Newcastle can take to improve their resource efficiencies between now and 2050.

European Urban Development

Urbanization has a distinctive and substantial environmental impact on land cover. For example, while agricultural land is also used for economic production; the abandonment of cropland will result in a landscape with predominantly natural characteristics in as little as 5 to 10 years. In comparison, urbanization generally results in the long-term sealing of surfaces and thus a complete change in landscape and ecosystem. Further, a majority of human activities are now concentrated in urban areas, a vast majority of economic production in Europe takes place in cities and processes of urbanization continue to take place in Europe. For these reasons, urbanization trends and impacts deserve particular attention in terms of the environmental and sustainability impacts that result from socio-economic development.

Figure 1: Growth of urban residential and economic areas in selected European Countries, 1990-2000 and 2000, 2006



EEA, 2010

Urbanization in Europe is generally high and in 2000, approximately 35% of European lived in cities with over 100 000 inhabitants, while a further 40% lived in smaller urban areas (EEA, 2010). As an indication of urban spatial growth, there was an average of 1000 km^2 land take-up by artificial surfaces (e.g. buildings, infrastructure and other non-permeable surfaces resulting from urban development) (EEA, 2010). Moreover, it is interesting to note that annual land take by artificial surfaces increased from 0.57% between 1990-2000 to 0.61% between 2000-2006 (EEA, 2010). However, as illustrated in Figure 1, these pan-European growth statistics are also characterized by large regional and national variations (from 0.01% in Montenegro to 3.2% in Spain) (EEA, 2009). Different patterns are also notable where small to medium growth rates (< 20%), coupled with aggregation of existing settlements, were mainly seen across central and eastern Europe, while high rates of growth (> 20%) - both in terms of aggregation of existing settlements and growth of newly built-up areas - took place in countries such as Spain, Portugal and The Netherlands. According to the EEA's 2010 *State and Outlook of Land Use in Europe*, transport infrastructure, and thus accessibility within and amongst urban areas, is viewed as the predominant driver of urban development. Other factors include population growth, changes in demographic structure (such as increases in the number of smaller households – and therefore floor space per capita), and weak regional planning systems. The latter refers to a lack of inter-municipal planning and cooperation between municipalities in many urban regions across Europe, which often leads to fragmented, self-interested decision making that drives sprawl.

The most direct impact of increased land consumption by urban development is the increase of soil sealing, which is largely dependent on the amount of land take-up and the population density in developed areas. Soil sealing in UMZs (Urban Morphological Zones) across Europe varies greatly, from 23% to 78%, whereby Eastern and Southern European cities tend to have relatively higher rates than northern cities (EEA, 2010). However, this trend is reversed when soil sealing per capita is considered, as population density tends to be higher in southern urban regions (EEA, 2010). Land-cover analysis from 2000 to 2006 shows that urban development through residential sprawl was more prevalent than infilling through brownfield development; while the intensity of land use in relation to population has decreased across Europe (EEA, 2010). Thus, while the numbers of people living in urban areas in Europe is increasing, the areas of cities are expanding at an even greater rate.

Due to the fact that urban land development involves increased resource dependencies that cannot be met locally; the SUME project is also concerned with the indirect impacts of urban expansion. For instance, the proliferation of low density residential settlements leads to greater car dependency and therefore increases in transport fuel consumption; just as larger living spaces and property sizes result in higher demands on energy, water and building materials. As such, the consumption of land not only has direct and longstanding impacts on landscapes and ecosystems, but these go hand-in-hand with wider issues related to climate change and increasing resource vulnerabilities.

Nevertheless, the future outlook for urban spatial development in Europe shows varied urban growth. Such a general and varied setting for future urban development adds credence to the scenario approach and is intended to provide realistic and comparable estimates between cities for policymakers and planners. In this regard, key questions include; what can be done in terms of metabolic performance of urban form to improve the development of existing city structures? And, if these optimal metabolic strategies are incorporated into development what will impact the impact be in terms of limiting the spread of urban regions over the next 40 years?

Methodology

The methodology for the scenarios was developed by the SUME lead partner, the Austrian Institute for Regional Studies and Spatial Planning (ÖIR). The following section provides a methodological overview of the scenarios. A more thorough methodology, as well as more detailed findings, is also available on the project website (www.sume.at) (SUME 1.2, 2010).

In selecting the cities to include in the study, a range of factors were taken into consideration. Each city in Europe, and around the world, is unique; however there are certain elements, such as urban forms and growth forecasts that help to group cities based on similar characteristics. This includes relatively dense cities with the prospect of growth, such as Marseille in Southern Europe, or cities with stable populations that continue to expand spatially, such as Newcastle in the UK, and cities that are forecasting considerable growth coupled with some expansion, as is the case with Stockholm in Northern Europe. At the same time, other more practical issues were also key factors in defining our scenario cities. This included the need to have a defined Urban Morphological Zone (UMZ), data availability and access to experts and practitioners.

The UMZ as a delimiting boundary of urban regions

The UMZ, as defined by the European Environment Agency (EEA) is delineated through Corine Land Cover Data as “A set of urban areas laying less than 200 m apart”. Thus, to be considered as part of the UMZ, there must be a discontinuous urban form with gaps of less than 200 m. This restricted the analysis of many of the cities of Western Europe, particularly in Belgium and the Netherlands, where discontinuous urban form stretched from one city to the next. Even with this drawback in mind, the greatest strength of using the UMZ was that it provided a consistent and comparative urban delimitation that more accurately reflected urban regions, as opposed to administrative boundaries.

Scenario Inputs (Drivers)
The urban development scenarios were created on the basis of the existing building stock and urban form in the respective case study regions. To identify the range of potential effects due to urban development policies and planning, two spatial development paths between 2000 and 2050 were defined for each city. The scenarios do not present forecasts; rather, their aim is to show the variation of potential development paths between a trend "BASE" scenario and a more ambitious and resource aware "SUME" scenario.

In projecting the scenarios, the primary drivers of urban spatial development were deemed to be population development, job development and the predicted increases in per capita floor space for residential (and indirectly) other uses. Put simply, the amount of population, employment and floor space development between 2000 and 2050 was used to generate a number of "additional dwellings" that would need to be constructed (and distributed) throughout each UMZ to accommodate growth. As such, the following data was compiled for each city: Corine land cover (2000), population and (residential and workplace density for a base year around 2000 and forecasts for 2050), per capita average floor space (household size) and distribution of high-level transport infrastructure. This was collected for the cells that make up the UMZs of the selected cities (ranging from about 100 to 790).

A crucial step in tailoring the scenario model to the context of individual cities involved the calibration of "additional dwellings" needed to accommodate local growth. Therefore, "housing types" were created for the SUME project. These were determined by defining distinct compositions of residential buildings based on average population densities of residential areas. This meant that housing forms with city-typical densities took on the very different historical urban development characteristics for each of the selected cities. For example, the average population density of the "single family homes" housing type was 2 350, 2 978 and 4 921 in Stockholm, Marseille and Newcastle respectively. Yet in contrast, Newcastle has the lowest density in the "dense multi story" housing type (9 801), compared with 17 003 in Marseille.

Variation in Future Urban Development: The BASE and SUME Scenarios
The methodological differentiations between the BASE and SUME scenarios are laid below along with the necessary assumptions used to complete them.

BASE scenario: The BASE scenario represents a continuation of current planning and policy with regards to density and urban form. Consequently, there was no strategy to focus densification around existing metro, unless emphasized in existing plans, while rail lines and population and job allocation took place until each cell reached its density threshold of its defined housing typology. Also, the density threshold of each on-site housing type in the BASE scenario was generally based on the average 'on-site density' from 2001.

SUME scenario: In the SUME scenario, more sustainable spatial development that focused on the metabolic performance of an urban region was emphasized. Planning policies were geared towards development along major public transport routes and infill projects to encourage a compact and integrated urban form. With this in mind, there were two key principles that guided increased allocation of population and jobs in the existing urban fabric. First, a higher densification threshold was set for all housing types to allow higher densities without implying fundamental transformation of the built environment. Second, the SUME scenario hinges on the increased densification of cells with good access to high-level public transport. Accordingly, all cells within a 10 minute walk of a transport station are "upgraded" by one housing typology and consequently, the density is not only increased by the increased density threshold in the SUME scenario, but also by the fact that the built environment is envisioned to become more dense around these transport nodes.

Building the Scenario

Given the uncertainties inherent to a 50 year perspective, the objective was to diminish the complexity of long-term development by showing the limitations that result from urban forms and structures inherited from the past. Cities are in a continuous state of transformation; however the rate at which they change and the manner in which the urban form will develop can be estimated using the scenario methodology developed here.

Starting with the UMZ delimitation and the current development context of each city, a simulation of future development is based on a step-by-step calculation where population and employment development is distributed until capacity is reached within the current UMZ. Any excess population (forecast for 2050) is distributed outside the UMZ, thus leading to the expansion of the urban fabric into previously undeveloped areas. The following description of the step-by-step calculations provides an outline of the general rules of the model and serves to describe the justifications behind each step in the scenario development. It is important to note that by their nature; models, scenarios and forecasts are rooted in assumptions that are necessary to project future outcomes. The BASE and SUME scenarios – based on population forecasts, employment projections, future infrastructure development, demand for larger living quarters, etc. - are no different. Accordingly, each step is undertaken with spatial development rules based on calculated assumptions, strengthened by local knowledge, for different potential development paths in the BASE and SUME scenarios.

As a point of departure, all large scale projects (over 500 dwellings in the planning or development stages are researched through city development plans and regional concepts, and it is assumed that they will be developed in the locations stipulated in planning documents. This identifies the current planning trends of a city and is used to allocate an equal number of “additional dwellings” in both the BASE and SUME scenario. Another implication is that these projects in the pipeline limit the freedom for future decision making in the period until 2050. Next, a local planner’s perspective was adopted to identify locations with strong potentials for major projects; primarily areas with good access to current or planned public transit infrastructure that do not compromise green spaces, recreational areas or other valued landscape. The same urban development corridors are defined for the BASE and SUME scenarios and cells situated in them are densified at least to a level characteristic of mixed-use, medium density urban living relative to each city. Therefore, the key difference in this step is the difference between threshold densities in the BASE and SUME scenarios.

Leading up to this point of the scenario process, the allocation of population and jobs was limited to specific areas where development was ongoing, planned or envisioned. The next step takes a more general perspective to “fill up” the remaining areas of the UMZ that are below their threshold density but are not restricted from further development due to existing land use. Here, the second substantial divergence between the BASE and SUME scenarios is implemented; all cells in proximity to high level public transit are filled to a higher threshold density and are densified by one housing type in the SUME scenario. As mentioned, this reflects a gradual structural change where densities are higher than in existing structures.

In the final step, excess population that cannot fit inside the current UMZ is distributed beyond existing limits; thus increasing the urban footprint. Density of this “sprawl” is calculated using the average density threshold between the two lowest housing types. As in previous steps, increased performance of the SUME scenario is insinuated by the higher threshold density.

The Scenario Cities

Marseille

As the oldest and second most populous city in France, Marseille has experienced generations of transformation. Spreading outward from the old port, the city's dense structure gives way to a more spread out, suburban form, the prevalent type of development during the latter half of the 20^{th} century. This has been restricted by the region's landscape however; which, with the Mediterranean Sea and the rugged Garlaban and Etoile mountain ranges, continues to be central in shaping regional development.

After a period of decline, Marseille is expected to grow from its present 940 000 residents to 1 135 000 by 2050 (MPM 2006). Coupled with this, an increase in living space, from the current 36 m^2 to 43 m^2 per person is expected to generate an additional 180 000 people looking for homes by 2050. In total, this means that there will be approximately 375 000 people seeking accommodation, and a related number of jobs, in Marseille between now and 2050. While this growth will undoubtedly place some strain on the region's existing urban form and resource consumption, the impact can be managed to some extent through the planning policies that are adopted throughout the region.

Table 1: Marseille UMZ – Basic Inputs

	2006	2050 BASE and SUME
Population	944 785	1 137 000
Jobs	358 557	431 505
Population change (in %)		+20.3%
Employment change (in %)		+20.3%
Population change (absolute)		+192 215
"Dwelling seekers" (leaving existing housing stock)		183 708
Total population to be allocated		**375 923**
Floor spacer per capita (m^2)	**36**	**43**
Increase in floor spacer per capita (in %)		+19.4%

Nordregio, 2010

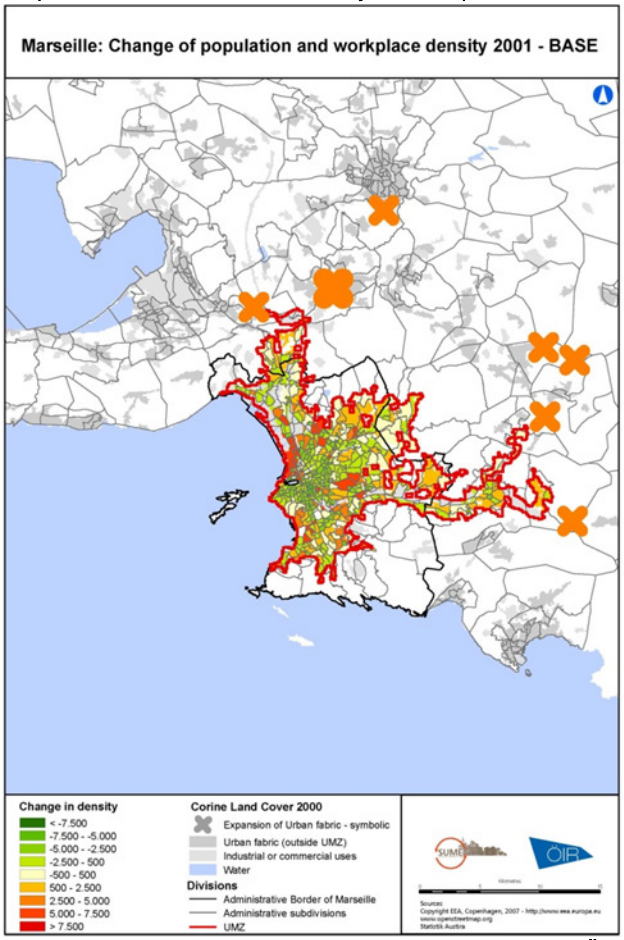
BASE & SUME Outcomes for Marseille

In considering Maps 1 & 2, a number of patterns become clear:

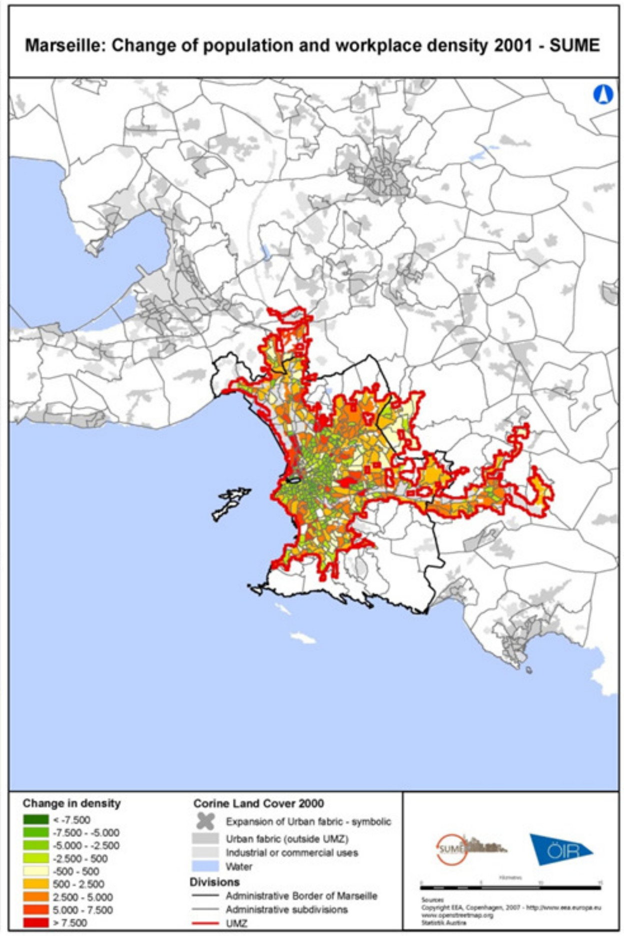
- Despite renewal efforts in central Marseille, the very high densities in the city centre are likely to decline moderately because of the demand for increased floor space per dwelling and out-migration. In spite of this, density will remain quite high.
- Densification in the BASE scenario is relatively evenly distributed throughout the UMZ, but areas of concentrated population increases are evident along the periphery of the existing UMZ.
- The SUME scenario sees a decline in central Marseille; however population redistribution leads to densification along transport corridors. This is particularly evident in the development of Aubagne, to the east, and in Septèmes-les-Vallons, which is north of the City of Marseille.
- Areas that show high densification in the BASE scenario have even higher densification in the SUME scenario. In this regard, pockets of densification that are evident in the BASE scenario are accentuated both in terms of their size (number of cells) and scale of density (colour) in the SUME scenario.

- Areas that show high densification in the SUME scenario but not in the BASE scenario are primarily located in proximity to good public transit. There is also some indication of concentric development just beyond the existing inner city, particularly northwest of the urban core. Development in the SUME scenario illustrates an emphasis on linking Marseille's urban fabric to neighbouring cities along transit corridors.

Map 1: Marseille BASE Density Development 2050



Map 2: Marseille SUME Density Development 2050

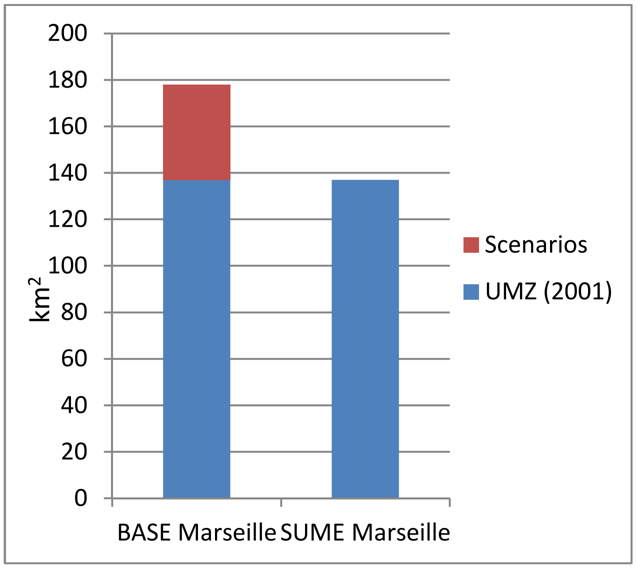


ÖIR, 2011

Impact on land consumption

With a total of 375 000 people to be accommodated, Marseille faces some challenges in providing housing for all within the UMZ. Maintaining the status quo, as is the case in the BASE scenario, will require more than 135 000 people to find housing beyond the existing UMZ. This would lead to a 41 km^2 or 30% increase in the UMZ urban fabric. Such development would be characterized by an increase in low-density housing thereby leading to greater sprawl and reduce the effectiveness of the public transit system beyond the inner city, where there is an emphasis on increased density, as illustrated by the flagship Euro Méditerranée project.

Figure 2: Marseille Urban Fabric Growth 2001-2050



Nordregio, 2010

Conversely, in the SUME scenario, all new residents can be allocated within the existing UMZ. The reduced land consumption would increase the likelihood that Marseille develops in a more environmentally sustainable manner, with higher densities in areas that have greater access to public transit, local shops and the inner city. Adherence to development policies that emphasize resource awareness would also limit the total area with sealed surfaces, thereby reducing the urban fabric's impact on the natural landscape. These results indicate that targeted strategic development would therefore limit Marseille's ecological footprint; literally, by covering less land, and in a wider sense, through the lower material and energy costs that would result from a denser urban form.

Energy consumption

The results from the BASE scenario indicate a stark increase in the percentage of people living in cells that are predominantly single use and more spread out. Conversely, the percentage of people living in these cells in the SUME scenario would be considerably lower. The increased sprawl and urban fragmentation that would accompany low density development would likely have a negative effect on accessibility to high level public transit, while also limiting the potential to travel by foot or by bicycle. This would result in greater car dependency, higher per capita energy costs per journey and longer travel times, which in turn would lead to increased energy consumption for transportation.

With higher densities and development along public transit corridors, the SUME scenario mitigates the problems associated with BASE scenario development. Rather, this scenario promotes alternative travel methods to the private car while also encouraging a more energy efficient urban form. An increase in ridership, as a result of public transit improvements, along with the polycentric development of mixed use areas further from the city centre and a general emphasis on higher living densities; the SUME scenario indicates that Marseille has the opportunity to prevent significant increases in transport and building related energy consumption.

Material consumption

Marseille's expected population growth, coupled with market demands for more living space are forecast to require the construction of 179 000 dwellings between 2006 and 2050. In constructing these units, the need for material consumption in terms of construction and infrastructure development is quite high.

In the BASE scenario, the Marseille UMZ is expected to grow by 30%. In doing so, infrastructure and buildings will be constructed, requiring greater material consumption. Further, the BASE scenario forecasts a greater proliferation of lower density building types, which are inherently less efficient in terms of material per resident, than higher density development. In contrast, the SUME scenario integrates all of the new dwellings between 2006 and 2050 into the existing UMZ. In doing so, there will be some material consumption as a result of construction and infrastructure development; however given the compact and strategic nature of such developments, the SUME scenario would reduce potential resource consumption, providing a more sustainable alternative, and reducing total costs on materials.

Marseille

The extension of the public transit system and the inner city renewal project, Euro Méditerranée, slated to house more than 38 000 people and provide 35 000 jobs, indicate that more resource aware planning is taking place. Sprawl continues however. Despite efforts to renew Marseille's dense structure, adherence to the current planning paradigm will still lead to growth in the existing urban fabric. A more ambitious, resource aware, plan could eliminate the need for expansion though. In this case, denser development in areas just beyond the urban core and along public transport corridors could ensure that all of the region's growth takes place within the existing UMZ. While there are many factors at play, paramount to Marseille's development is the question of how willing the Marseillais are to maintain, and beyond the city centre, increase, density levels or further embrace trends towards significantly more living space.

Newcastle

Bound to the east by the North Sea, the area around the Tyne and Wear rivers urbanized during the 19th century. Driven primarily by industrial development, a relatively dense urban core of heavy industry was established along the rivers, surrounded by residential areas. Over the past 50 years, the forces of globalization have reshaped Newcastle's economy away from heavy industry towards the service and knowledge economy.

Economic change has contributed to an increase in underused economic and residential buildings in the city core and sprawled development towards the margins of the city. As a result, the inner city of Newcastle, while containing a vibrant commercial zone, has been hollowed out and faces challenging socioeconomic problems such as high unemployment, poverty, deprivation and the complete market collapse of some neighbourhoods. This has prompted people and businesses to shift their investment toward the suburbs in search of better conditions, which has a direct impact on car dependency. Despite having a local Metro, commuting ridership was most recently measured at 21% in 2001 (ONS, 2001).

The population in Newcastle fell by 5% between 1981 and 2008; however it has begun to rebound and is expected to return to its 1981 level by 2030 (TWRI, 2009). A population increase from the current 1 060 000 to 1 180 000, coupled with a per capita increase of living space per person, from 40 m^2 to 45 m^2 means that there will be approximately 260 000 dwelling seekers between now and 2050. Efforts to respond to this growth by re-focusing development toward the city centre exist, yet inner-city projects face competition from suburban communities offering large detached and semi-detached homes, which are attractive in Newcastle's housing market.

Table 2: Newcastle UMZ - Basic Inputs

	2001	2050 BASE and SUME
Population Jobs	1 058 070 468 247	1 182 922 530 656
Population change (in %) *Employment change (in %)*		+11.8% +11.8%
Population change (absolute) "Dwelling seekers" (leaving existing housing stock) **Total population to be allocated**		+124 852 132 259 **257 111**
Floor spacer per capita (m^2) *Increase in floor spacer per capita (in %)*	**40**	**45** +12.5%

Nordregio, 2010

The Newcastle Scenario: A Methodological Amendment
Perhaps the most interesting component of the Newcastle scenario is that the development of suburban communities continues to be a dominant means of meeting demand for housing and employment space in Newcastle. As such, many housing and job developments are potentially going to be constructed on undeveloped land on the periphery of the current Newcastle UMZ. Due to the fact that these projects are certain to be instrumental in helping Newcastle meet future housing demand, they need to be included in the scenario assessment. However, this provides an opportunity to evaluate the impact that SUME oriented development could have on reducing the expanse of urban development.

Therefore, the BASE scenario pursues the status quo, whereby greenfield projects tabled for peripheral locations in Newcastle, North Tyneside and Sunderland will eventually be developed. In contrast, the SUME scenario, based on the aim of attracting development inward or in proximity to public transit, assumes that a transport extension can and will be implemented to the west of the city centre. As such, the projects developed outside the UMZ in the BASE scenario are transferred to the currently underused areas in and around Benwell-Scotswood in the SUME scenario. Whereas other case study city scenarios use the same population figures and locations for the first step in the BASE and SUME scenarios, this approach exercises the key methodological adaptations where the number of planned or ongoing projects is the same in both scenarios, but their locations are different and an additional public transit line is constructed in the SUME scenario.

BASE & SUME Outcomes for Newcastle
A number of insights can be drawn from Maps 3 and 4:

- There is little densification in the city centres of Newcastle and Sunderland and the growing demand for increased floor space per dwelling suggests that population density could actually fall in these areas.

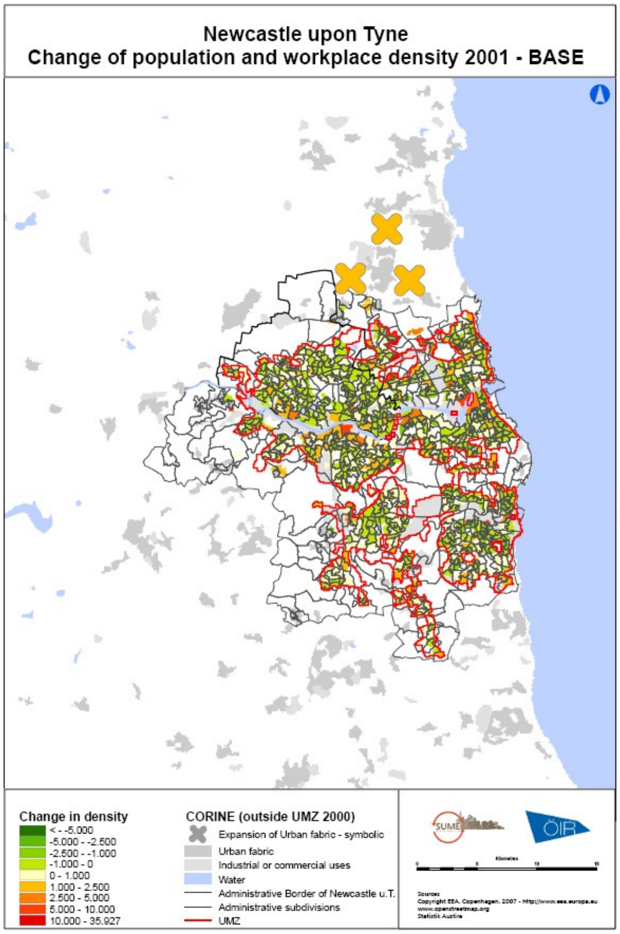
- Densification in the BASE scenario is distributed throughout the UMZ, but areas of concentrated densification are evident in Gateshead and South Tyneside (to the south of the River Tyne).

- The SUME scenario foresees stagnant or decreasing density in various cells that are not proximate to the city centre or Newcastle's Metro. These cells are particularly evident to the south of the river Tyne in cells that are not proximate to high level transit.

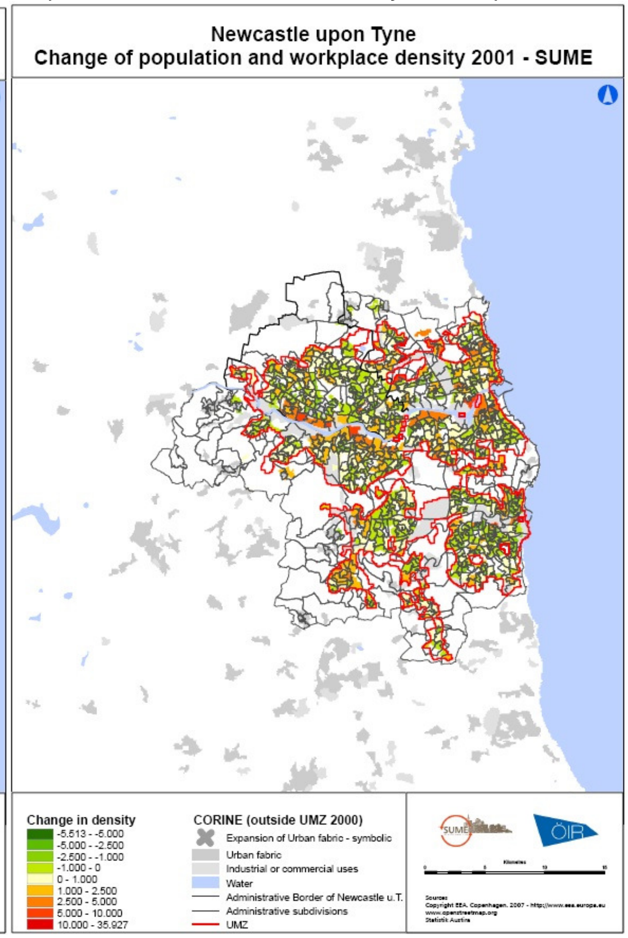
- Areas that show high densification in the BASE scenario have even higher densification in the SUME scenario. Areas of densification found in the BASE map are greater in terms of size and density in the SUME map.

- Areas that show high densification in the SUME scenario but not in the BASE scenario are concentrated in two areas. One along the proposed development corridor running to the west of the city centre, through Benwell and Scotswood, resulting from the hypothetical extension of the Metro network. The second along the development corridor running to the south of the city centre resulting from the suggested development of the existing rail network with additional stations and more efficient rail service.

Map 3: Newcastle BASE Density Development 2050

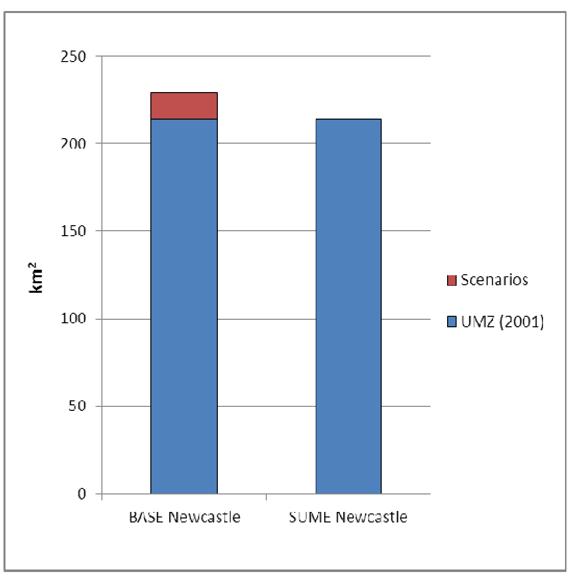


Map 4: Newcastle SUME Density Development 2050



ÖIR, 2010

Figure 3: Newcastle Urban Fabric Growth 2001-2050



Nordregio, 2011

Impact on land consumption

Without including the current building projects that are being constructed outside of the UMZ, the BASE scenario envisions that population development of 11.8% in the Newcastle UMZ will extend the UMZ by 6.67% up to 2050 (15km^2). By contrast, the SUME approach could accommodate the population growth and demand for additional living space inside the current UMZ, in addition to an extra 45 123 residents. Based on the population density used to calculate the growth of the UMZ in the BASE scenario (4 921 residents/km^2), this implies that there would be 9.2 km^2 of additional developable space to accommodate residents, jobs or other functions within the UMZ in 2050. Thus, the difference in land consumption between the two Newcastle scenarios amounts to approximately 25km^2 in 2050.

These statistics, paired with the understanding of the amount of underused land due to vacant dwellings, indicate that following a SUME development pattern that accounts for metabolic flows can have a substantial impact on land consumption regardless of the degree of population development. This is especially valid considering that dwellings continue to be vacated or torn down inside the UMZ.

Energy consumption

The continued development of low density housing, as is pursued in the BASE scenario, is seen to have a negative impact on energy consumption in Newcastle. For example, poor access to public transit promotes car use, while a lack of proximate commercial facilities reduces the likelihood that reduces the likelihood that individuals will choose to walk or cycle. Inversely, mixed use areas are more likely to decrease trip lengths and promote trips where multiple trips are combined. Based on the statistic that 58% of the families operate at least one car and 59% of those employed use a car to commute to work, it is certain that realizing a SUME perspective for urban development would significantly reduce transport fuel consumption in the Newcastle UMZ (ONS, 2001). Savings would result from both a reduction in overall trips by car and reduced trip length.

As an aging building stock continues to be replaced with new structures, energy consumption in buildings is also a central issue for limiting future energy demand. While the suburbanizing trend creates larger dwellings that have proportionately higher energy demand, a SUME approach of dense urban communities promotes more efficient uses of space, both inside and outside the home. If a SUME perspective can gradually replace the current demand for larger suburban dwellings it is assumed that regardless of the performance of buildings, the energy savings would be substantial.

Material consumption

In terms of a development approach that prioritizes metabolic flows - one that operates under the precondition that materials are needed to service development both inside and outside of the UMZ - the most crucial interest area focuses on the trade-offs between peripheral greenfield development and the regeneration of the vacated urban pockets in the UMZ.

The largest project currently underway in the Newcastle UMZ, Newcastle Great Park, is a greenfield development at the northern periphery of the UMZ. The development is promoted as a vibrant mixed-use community where people can live, work, meet their daily needs and enjoy leisure activities in the same urban area. While the attention to more sustainable living situations is notable, the development exemplifies the material consumption that is required when developing on greenfield sites. Not only does a local road network have to be developed for the area, but significant expansion of the surrounding infrastructure is necessary to accommodate the development. Similar investments are required for freshwater distribution and wastewater collection, as the local carrying capacities are not high enough to sustain the increased demand on the infrastructure. In contrast, a focus on existing underused areas allows for the use of existing road, water distribution and wastewater collection infrastructure. This promotes more efficient use of materials along with reduced land consumption.

Newcastle

While the policy discourse in Newcastle indicates a more resource aware planning mentality, the reality is that planning ideals and market forces continue to dovetail. Currently, there are no specific plans to extend Metro coverage in Newcastle due to the lack of available public capital, and the demand for detached housing with private gardens is exacerbating urban sprawl. Considering the large plots of land available for redevelopment and the relatively slow growth rate in Newcastle, this is a significant expansion. However, this pattern can be reversed if planners and policy makers are able to facilitate a transition towards more resource aware approaches based on public transit provision and higher density living.

Stockholm

Consisting of thirteen islands, a series of associated waterways and a number of vast green spaces, Stockholm's unique geography underlines the importance for solutions that are tailored to the local context. Development has expanded from Gamla Stan (Old Town) and has followed a star-shaped form, whereby five fingers have spread across the landscape, punctuated by green wedges and bodies of water. These open spaces ensure rapid access to nature for city dwellers. They figure prominently in Stockholm's identity, and are fiercely defended against encroachment. These spaces are seen as an important reason for the high quality of Stockholm's urban area, but also limit potential inner city development and lead to greater distances between various areas; which heighten the costs associated with transport infrastructure and increased travel times.

The challenge of accommodating new residents has grown in recent years, particularly in the inner city, where after a number of decades of out-migration, the housing market has exploded. This trend is expected to continue until at least 2050, by which time the region is forecasted to grow by 565 000 residents, or more than 40% (RTK, 2009). Further, an additional 160 000 people will need to find housing as a result of an increase in living spaces from 40 m^2 to 45 m^2. In total, this means that Stockholm will have to accommodate an additional 725 000 people, something that will place significant strain on the region's resource efficiency. The challenge is compounded by the limited space that is available for densification in the inner city of a decidedly monocentric urban form.

Table 3: Stockholm UMZ - Basic Inputs

	2001	2050 BASE and SUME
Population	1 280 450	1 848 000
Jobs	763 629	1 102 000
Population change (in %)		+44.3%
Employment change (in %)		+44.3%
Population change (absolute)		+567 550
"Dwelling seekers" (leaving existing housing stock)		160 056
Total population to be allocated		**727 606**
Floor spacer per capita (m^2)	**40**	**45**
Increase in floor spacer per capita (in %)		+12.5%

Nordregio, 2010

BASE & SUME Outcomes for Stockholm

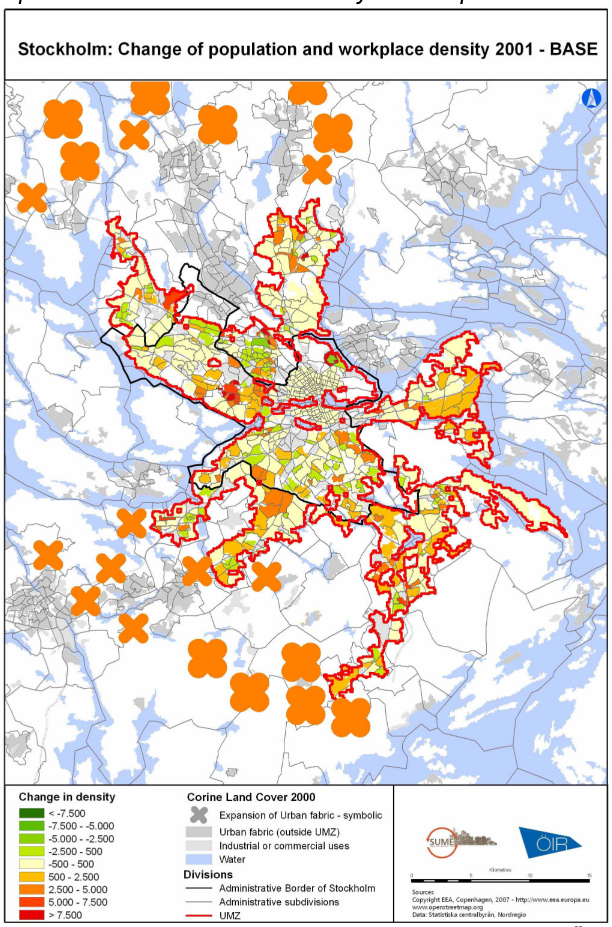
The following points are of particular interest when looking at Maps 5 and 6:

- Densities in the inner city remain stable. This is an outcome of densification efforts and a high market demand for housing in the area, which mitigates floor space increases.
- Both the BASE and SUME maps highlight the densification of many cells near the inner city, with a particular emphasis on the area immediately west of the core, including the municipalities of Bromma, Sundbyberg and Solna.
- The maps also highlight the densification of other growth cores in the Stockholm UMZ as a result of the region's polycentric growth strategy. Most notably, high growth rates in both the BASE and SUME scenarios are evident along the transport corridor toward the regional growth core of Haninge, south-south east of the inner city. Additionally, the

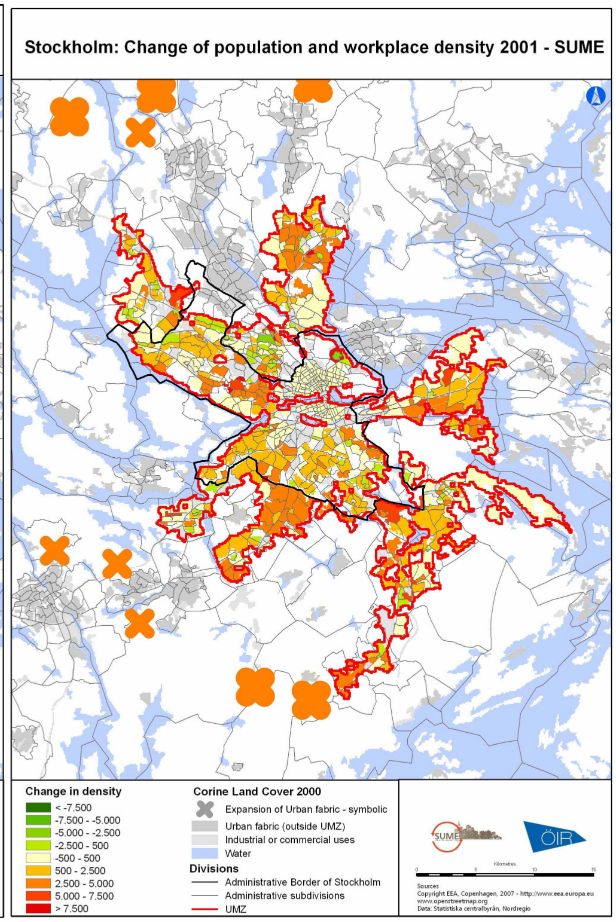
regional growth cores of Täby, Fleminsberg, Kungens Kurva and Barkaby also show significant growth.

- There is an emphasis on particular growth areas in the SUME scenario. Such growth is notable on the southern transport corridor toward the regional growth cores of Haninge and Huddinge, and the cells surrounding Täby, to the north, Flemingsberg, to the south.

Map 5: Stockholm BASE Density Development 2050



Map 6: Stockholm SUME Density Development 2050

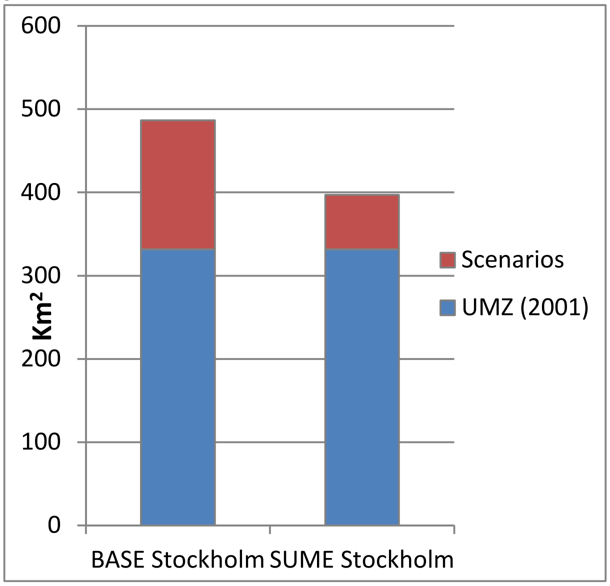


ÖIR, 2011

Impact on land consumption

Even though the SUME scenario provides a basis for more sustainable urban growth in Stockholm, the fact that the city's population is expected to grow by almost 45% between 2001 and 2050 means that the UMZ will expand in both scenarios. The BASE foresees UMZ growth of 46.7%, or 155km^2, accommodating 460 000 people. This expansion would be typified by rather low-density, suburban areas that would cause considerable fragmentation in the urban fabric, despite the densification that is already planned in current or upcoming projects.

Figure 4: Stockholm Urban Fabric Growth 2001-2050



Nordregio, 2010

In comparison, the same population increase in the SUME scenario envisions growth of the UMZ by only 19.6%, or 65km^2, that would be home to 250 000 people by 2050. This is based on the concept that growth could be focused on areas with good access to public transit (along transit corridors and regional cores identified in RUFS 2010) and that higher density areas could be developed outside the inner city. Accordingly, the future growth that takes place outside the UMZ will be less-fragmented than in the BASE scenario, leading to improved public transport and local access services and amenities.

Energy consumption

The high level of growth outside the UMZ predicted in the BASE scenario is expected to take place primarily through low density development. Coupled with this, the increased fragmentation predicted in the BASE scenario will undoubtedly affect decrease the proportion of the population with access to high-level public transport. Average travel times are also likely to be much longer than in 2001. Consequently, energy consumption for transportation will increase even with the focused urbanization of regional sub-centres in the BASE scenario.

These unfavourable impacts would be mitigated to some extent in a SUME scenario that concentrates development around transport corridors and increases overall density; especially in areas surrounding regional sub-centres. Coupled with the continued expansion of high-level public transit, increased energy consumption for transport could be reduced significantly.

Material consumption

Due to the expected population growth in Stockholm, the need for material consumption in terms of construction and infrastructure development is high. This has a negative impact on costs as more material is needed to service the extending infrastructure. The 46.7% growth of the UMZ in the BASE scenario indicates that this is an important issue where sustainable urban development strategies could have a strong impact on future metabolism.

Focusing on strategic densification with a SUME strategy leads to a lower material consumption as the expansion of the UMZ is reduced by 58%. Accordingly, the need for technical infrastructure is reduced and the social infrastructure could be more concentrated and therefore more cost efficient.

Stockholm

In accommodating this growth, Stockholm has several assets. The region's public transit network is quite well developed, is well used and is closely linked to the region's continued spatial development. Planning authorities are aware of the challenges at hand and have responded with active strategies. In the inner city, this has led to infill projects on brownfield sites and other efforts to promote densification. At the regional scale, a strategy to promote a more polycentric development pattern that corresponds with the transit network and encourages a more balanced structure has been implemented to reduce dependence on the inner city in terms of employment, leisure and transport. These initiatives indicate that planning authorities in

Stockholm have recognized the need to foster more resource efficient strategies to limit the adverse effects that can accompany growth.

The sheer scale of the population growth that is forecast for Stockholm is very likely to cause some decline in the region's overall resource efficiency however. While considerable efforts have been undertaken to promote environmental sustainability in the region; continuation of current planning strategies in the face of significant growth are forecast to cause considerable expansion of the urban fabric between now and 2050. Conversely, an even greater focus on resource aware development, specifically through increased, though realistic, densities concentrated along existing public transport corridors and around the inner city could have less of an impact on the region's resource consumption. Planning bodies in Stockholm have adopted fairly ambitious strategies for environmental sustainability; however as one of the fastest growing cities in Europe, even greater efforts will be required if Stockholm is to maintain its position among the greenest cities on the continent.

Conclusion

An evaluation of the BASE and SUME development patterns in three considerably different cities presents a number of useful findings. First, it is impossible to underestimate the importance of a city's context; in terms of geography, population and economic development, planning approaches and demography, to name a few important factors. In a concrete sense, the gradual pace with which cities transform ensures that the existing urban form will have a significant influence on the manner in which the urban fabric develops between now and 2050, and beyond. A similar assertion can be made of economic and population development, as the extent of growth, or decline, affects the rate and intensity that a city and it's metabolic efficiency can be altered. Related to this, the demand for greater living space that is evident in each of the scenario cities places an addition burden on efforts to develop more sustainably. These factors all figure prominently in a cities capacity to promote resource efficiency.

The scenarios offer a glimpse into what Marseille, Newcastle and Stockholm could look like in 2050, but also provide a strong indication of current planning practices in these cities. Efforts to promote greater resource efficiency, through transit oriented development or increased densities, for example, are evident in Stockholm and Marseille. Conversely, while it is recognized as an important issue, more resource efficient planning is not evident in Newcastle. This was reflected in this study through the need to modify the SUME scenario to demonstrate what could be possible if different approaches came to be prevalent. Findings from Stockholm and Marseille suggest that while market forces play a significant role in urban development, public authorities have considerable influence as well.

A number of important similarities can also be recognized, however. Paramount to this is the scenario evidence that the continuation of the status quo in planning will result in more low density developments, and the associated sprawl, in all three cities. This will result in higher land, energy and resource consumption. While this is a potential development path, the SUME scenario also demonstrates that each city, despite the range of challenges they face, has the opportunity to pursue an approach that further limits future resource consumption.

The impact that cities have on the environment will continue to grow as their influence increases. This is likely to cause certain negative externalities, yet there is also significant potential for urban regions to help solve environmental challenges. This paper has sought to illustrate how cities can better handle one such issue, resource consumption and in doing so, has emphasized how cities can influence their own destinies. Such influence will depend in large part on each city's willingness and capacity to handle this challenge.

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For more information about the EU FP-7 SUME project, please consult www.sume.at .

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