Sustainable urban (re)development
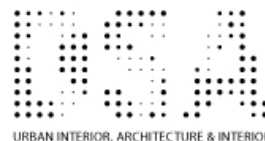
Experiences and recommendations for an integral policy approach

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Summary

The urbanization process in large parts of the world requires an adequate urban development response. This might be found in the modern concept of sustainable urban (re)development, which adequately integrates spatial planning, socio-economic stimuli and ecological solutions. The study provides policy makers with insights and powerful examples of sustainable urban (re)development and of the underlying strategies.

Based on numerous earlier exercises, relevant indicators and parameters are listed, clustered and incorporated into a framework that can be used to assess actual situations.

In the project the following definition is used: "*Sustainable urban (re)development offers a living environment of high spatial, physical and natural quality, where people can develop themselves well, both economically and socially, and where the environment is considered optimally by low emissions, water management, etc. in such a way that the total system is continuable*".

Based on this definition the indicators and parameters are grouped into three qualities; physical and spatial quality, socio-economic quality and ecological quality & flows. Important indicators in the first category are density, mixed area use and morphology. Examples in the second category are prosperity, well-being and the level of amenities. Air quality, energy and water consumption and travel modes are some of the indicators in the last category.

Six cities are selected and analysed: Amsterdam, Copenhagen, Ottawa, Rotterdam, San Francisco and Vancouver. The main consideration to select these cities is that the project is part of a Memorandum of Understanding between Canada and the Netherlands. Another reason is that these cities are considered to be exemplary front runners with respect to sustainable urban development. The analyses of the cities are intended to obtain a better understanding of the effectiveness of sustainable urban development strategies in general and not to judge, rank or benchmark the cities in any way.

The cities show interesting similarities and differences in their approaches as well as unique pilots, which are elaborated upon in the report. The analyses lead to the following general findings, conclusions and recommendations.

A first conclusion is that more integral sustainability approaches yield the best overall results. This might partly be due to the fact that these approaches are generally better integrated in the total policy processes; e.g. some cities use a sustainability checklist for every municipal decision taken on the development of the city. Another general conclusion is that the most successful approaches start from the social and physical health of the citizens; sustainable urban (re)development should be organized around people, rather than around cars or around GHG protocols, etc.

In many cases municipalities also have to look beyond municipal boundaries, as they serve a much wider area with harbour and industrial complexes. The development of these areas requires close co-operation between the organisations involved and the federal government.
From these two angles (the citizens and the wider importance of the city) an integral vision for the future of the city can be drawn-up. The resulting strategy for the urban sustainable development is then laid down in an integral strategy document.

The strategy will have to be translated into a concrete set of actions. Packages of building blocks will have to be composed for the realisation of the policy intentions. Success factors for this process are leadership and enthusiasm, long-term consistency and citizen participation.

Figure 1   Building blocks and points of interest for a successful approach
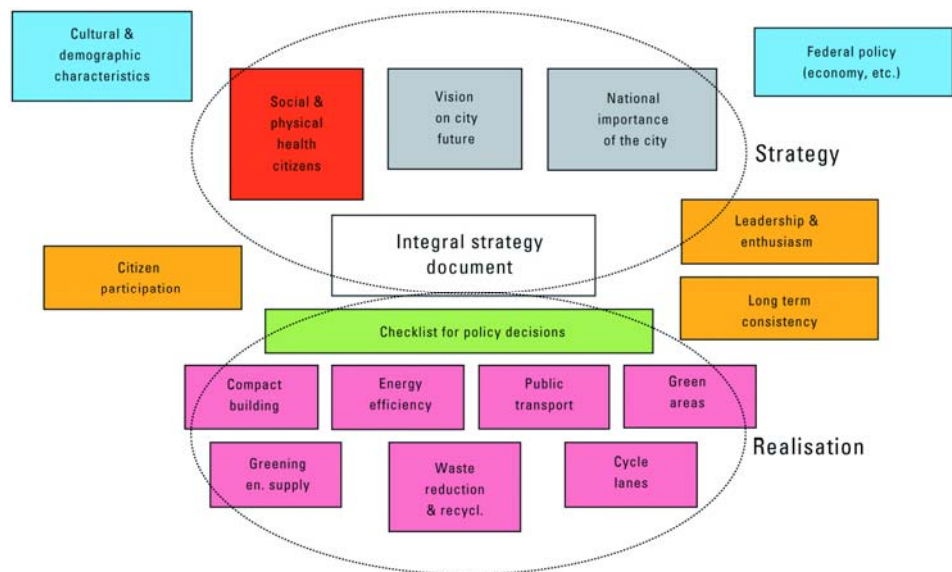
Compactness and (eco)-density are important, though not sufficient, characteristics of a sustainable city. It is crucial to find the right balance for issues like affordability, liveliness, economic vibrancy, etc.

Though good results can be realised by approaches that create conditions and stimulate people, this does not yield sufficient results in all sectors and for all groups of people. This is one of the reasons that several cities additionally tend towards more mandatory measures, to deal with the more difficult dossiers and with the laggards. Also in this field co-operation at regional, federal or even international level is required.

The report ends with a set of guiding principles and concrete buildings blocks for sustainable urban (re)development policies. These guiding principles and concrete elements can be used to improve the approach in virtually any city. With some extra elaboration, the principles and checklists might be developed into a serious measuring tool for the effectiveness of actual sustainable urban development policies in cities.

Samenvatting

De sterke mate van urbanisatie, in grote delen van de wereld, vereist een adequate respons qua stedelijke ontwikkeling. Dit antwoord kan gevonden worden in het moderne concept van duurzame stedelijke (her)ontwikkeling, dat op een doeltreffende wijze ruimtelijke planning, sociaaleconomische stimuli en ecologische antwoorden integreert. Deze studie verschaft beleidsmakers inzicht in en krachtige voorbeelden van duurzame stedelijke (her)ontwikkeling en in onderliggende strategieën.

Op basis van vele eerdere exercities, zijn relevante indicatoren en parameters verzameld, geclusterd en vervat in een raamwerk dat gebruikt kan worden om bestaande situaties tegen het licht te houden.

In het project is de volgende definitie gehanteerd: "*Duurzame stedelijke (her)ontwikkeling biedt een leefomgeving van hoge ruimtelijke, fysieke en natuurlijke kwaliteit waarin mensen zich economisch en sociaal goed kunnen ontwikkelen (qua voorzieningen en veiligheid) en waarin het leefmilieu optimaal wordt gediend door lage emissies (stoffen, hitte en geluid), waterbeheer, e.d. zodanig dat het geheel volhoudbaar is*".

Uitgaande van deze definitie zijn de indicatoren en parameters gegroepeerd naar drie facetten; de fysieke en ruimtelijke kwaliteit, de sociaaleconomische kwaliteit en de ecologische kwaliteit & stromen. Belangrijke indicatoren in de eerste categorie zijn dichtheid, meervoudig ruimtegebruik en de morfologie. Voorbeelden in de tweede categorie zijn welvaart, welzijn en het niveau van voorzieningen. Indicatoren in de laatste categorie zijn lucht kwaliteit, het verbruik van energie en water en de reismodi.

Zes steden zijn geselecteerd en geanalyseerd: Amsterdam, Kopenhagen, Ottawa, Rotterdam, San Francisco en Vancouver. Hoofdreden om deze steden te selecteren is dat het project onderdeel vormt van een "Memorandum of Understanding" tussen Canada en Nederland. Een andere reden is dat deze steden worden beschouwd als koplopers en voorbeelden met betrekking tot duurzame stedelijke (her)ontwikkeling. De analyses van de steden zijn alleen bedoeld om een beter begrip te krijgen voor de effectiviteit van de duurzame stedelijke (her)ontwikkeling strategieën in het algemeen en niet om de steden te beoordelen of onderling te rangschikken op welke manier dan ook.

De steden tonen interessante overeenkomsten en verschillen in hun benaderingen en unieke pilot projecten, die uitgewerkt worden in het rapport. De analyses leiden tot de volgende algemene bevindingen, conclusies en aanbevelingen.

Een eerste conclusie is dat meer integrale benaderingen van de duurzaamheid tot de beste overall resultaten leiden. Dit kan deels een gevolg zijn van het feit dat deze benaderingen in het algemeen ook het best zijn geïntegreerd in de totale beleidsprocessen; zo gebruiken sommige steden een duurzaamheids- checklist voor ieder besluit over de ontwikkeling van de stad. Een andere algemene conclusie is dat de meest succesvolle benaderingen starten vanuit aandacht voor het sociale en fysieke welzijn van de burgers; duurzame stedelijke (her)ontwikkeling moet eerder georganiseerd worden rond mensen, dan rond bijvoorbeeld auto's of emissiedoelstellingen.

In veel gevallen moeten de steden ook verder kijken, aangezien zij een veel groter gebied bedienen met bijvoorbeeld voorzieningen en havenindustriële complexen. De ontwikkeling van deze gebieden vereist nauwe samenwerking met de betrokken organisaties and de nationale overheid.

Vanuit deze twee invalshoeken (de burgers en het bredere belang van de stad) kan een integrale visie worden opgesteld rond de toekomst van de stad. De resulterende strategie voor de duurzame stedelijke ontwikkeling wordt dan verwoord in een integraal strategiedocument.

De strategie moet dan nog worden vertaald in concrete pakketten van bouwstenen om het beleid te realiseren. Succesfactoren bij dit proces zijn leiderschap en enthousiasme, lange termijn consistentie en burgerparticipatie.

Figure 2   Bouwblokken en succesfactoren voor een effectieve aanpak
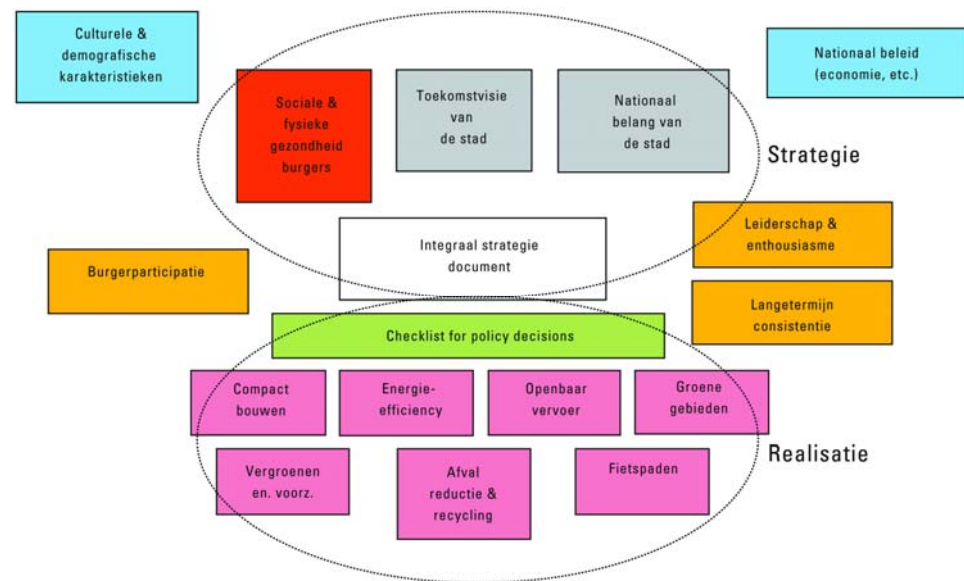
Compactheid en (eco)dichtheid zijn belangrijke, maar geen doorslaggevende eigenschappen van een duurzame stad. Het is vooral van belang de juiste balans te vinden tussen zaken als betaalbaarheid, levendigheid, economische vitaliteit, e.d.

Alhoewel er goede resultaten bereikt kunnen worden met benaderingen die voorwaarden scheppen en stimuleren, levert dit niet voldoende resultaat op in alle sectoren en alle doelgroepen. Dit is één van de redenen dat verscheidene steden aanvullend inzetten op meer verplichtende maatregelen, als antwoord op de moeilijkere dossiers en met de achterblijvers. Ook op dit terrein is samenwerking op regionaal, nationaal of zelfs internationaal niveau vereist.

Het rapport besluit met een set leidende principes en concrete bouwstenen voor duurzaam stedelijk (her)ontwikkelingsbeleid. Deze principes en bouwstenen kunnen worden benut om de aanpak te verbeteren in willekeurig welke stad. Met enige extra uitwerking kunnen de principes en checklists ook ontwikkeld worden tot een algemene maatstaf voor de effectiviteit van het duurzame stedelijke ontwikkelingsbeleid in steden.

1 Project objective and approach

1.1 Background

The world is urbanizing. Already more than 3.3 billion people worldwide live in large cities. This urbanization process is caused by an autonomous migration of people towards cities, leaving other regions empty. This process is expected to continue and requires an adequate urban development response.
In addition, the cities themselves are in constant transition as well.
Old functions lapse, sometimes leaving derelict areas and new functions need to be integrated. This requires adequate urban development strategies (responses). The solution might be found in the modern concept of *sustainable urban (re)development*. Sustainability hereby encompasses a wide scope of topics, varying from spatial planning, social and economic strength and ecological issues. Sustainable urban (re)development contributes to an ecologically sustainable, socially liveable and economically healthy environment.

The coordination of the Dutch policy in this area falls under the Ministry of Housing, Spatial Planning and the Environment (VROM) and its Directorate General for Housing, Communities and Integration (WWI). The policy field is trans-disciplinary as it affects the working spheres of the Ministry of VROM (all levels), the Ministry of Economic Affairs (economic development and energy), the Ministry of Transport, Public Works and Water Management (mobility), the Ministry of Social Affairs and Employment (social policy), the Ministry of Health, Welfare and Sport (health care) and the Ministry of the Interior (safety).

The Ministries VROM and WWI work on the issue, through various programs, particularly at national level. As part of a Memorandum of Understanding (MOU) with Ontario Canada, the Ministry of VROM wishes to gain a better understanding for the international experiences with sustainable urban (re)development. This understanding should be based on best practice examples, on the main parameters and indicators and on the integral policy approach that underlies the positive trends of sustainable urban (re)development.

1.2 Problem definition

In assessing sustainable urban development schemes it is always the question to what extent the approach contributes in three key areas: social liveability, economical health and ecological sustainability of the city? This question is difficult to answer since the impact might partly be positive and partly be negative. For example, compact building in cities has the advantage of limited use of space and concentrated public amenities, while at the same time it challenges the quality of living. Another example is that cities have the positive power to accommodate large groups of migrants, which however also includes the risk of social segregation.

On both national and international level many groups are working on answers and solutions to the above mentioned dilemmas. Most of them primarily focus on one policy component, others strive for an integrated approach, but there is still not a clear crystallized overview of the actual status.

Consequently, research on the lessons that can be learnt from relevant international exemplary cities could provide valuable insights; with respects to in the underlying success and failure factors for example.
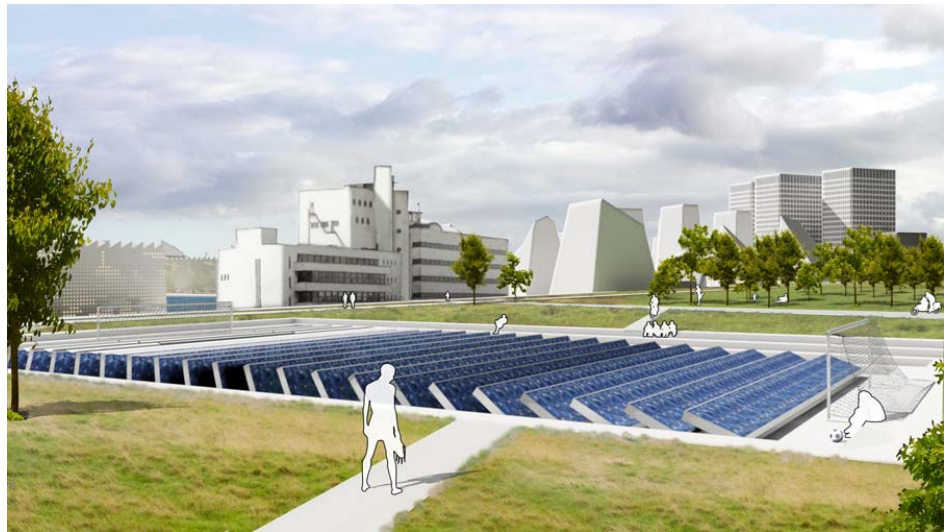
Doepel Strijkers Architects.
Renewable city 2040 – Merwe Vierhavens, Rotterdam.

1.3   Project objective

The main project aim is to provide policy makers with a better understanding of effective examples of sustainable urban (re)development and the underlying governmental interventions. The primary target group in the Netherlands encompasses the responsible policy makers at the Ministries of VROM and Economic Affairs.
A first sub-objective was to develop a set of parameters and indicators that could be used to select the exemplary cities. A second sub-objective was the synthesis of lessons from the exemplary cities into a set of clear images and good practices, which could be used in a presentation for the GLOBE 2010 conference in Vancouver and other meetings in Canada, in the context of this conference.
As a consequence the project focus was on exemplary cities in Canada, in the United States and North-West Europe. Obviously, good practices from elsewhere in the world were taken into account as well, but only if these offered lessons that were "not to be missed".
The end result of the project provides policy makers with a good documented base for the route towards a more sustainable urban (re)development strategy/approach.

1.4   Key concepts of sustainable urban (re)development

Sustainable urban (re)development is ecologically sustainable, socially liveable and economically healthy. Under these general denominators a large number of more operational principles and issues like space use, health, affordability, feedstock ("food" or "food production"), safety, mobility, environmental impact, etc. are included and interconnected.
Figure 3 gives an indication of these terms in the shell around the "core" of sustainable urban (re)development.

In practice the issues come together in the context of concrete policy questions around the approach of social issues like housing, the restructuring of old urban districts (both residential areas and industrial areas), water, waste and energy management and the objective of a high quality living environment for residents. The issues also play a role in the positioning of new urban areas and the choice for future building concepts, mobility solutions, energy supply, etc.

1.5   Project approach

The project was carried out by a consortium, consisting of CE Delft, Doepel Strijkers Architects (DSA) and the Centre for Sustainability of the Nyenrode Business University.

The project was intended to be a practical exploration, rather than a scientific research project. As a consequence most data and descriptions in this report have a qualitative character, rather than quantitative. This approach was inevitable because of the limited running period for the project[1], but it was also consciously chosen for, based on the notion that a more scientific approach would not automatically lead to a better result.

Work on the project was divided into five main steps. The process is described below and the process and report structure are illustrated in Figure 4.

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[1]   Official start project 31 December 2009, the GLOBE 2010 is at 24th-26th March 2010 in Vancouver.

Figure 4   Project process and report structure
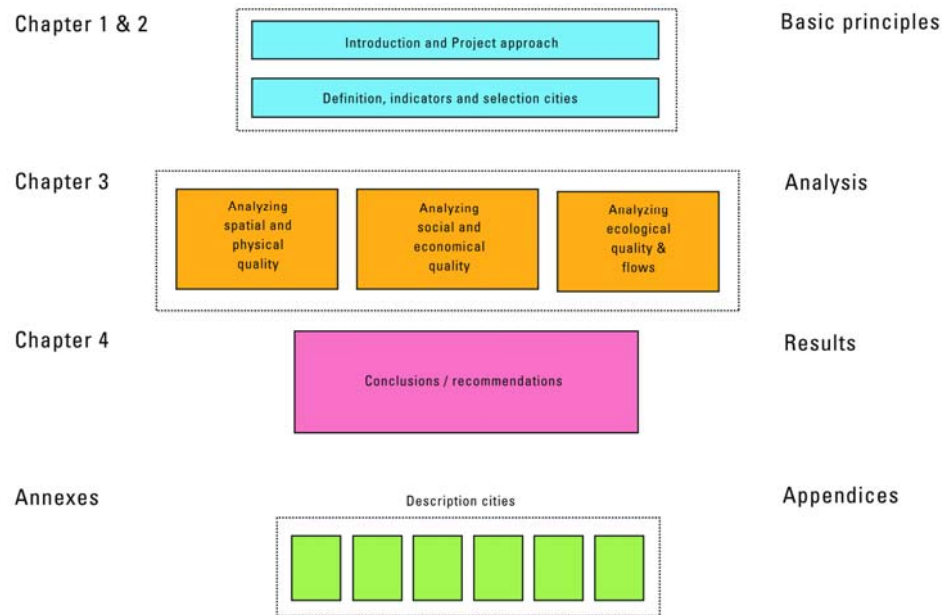
1.5.1 Definition, indicators and parameters sustainable urban (re)development

For the project we have developed our own definition of sustainable urban (re)development. This definition is based on and is in line with existing definitions, but goes a little bit further than all well-known alternatives.
At the same time a general list of indicators and parameters was drawn-up, based on the three basic requirements; ecologically sustainable, socially liveable and economically healthy. This listing is included in the report and is based on structural analysis of existing ranking lists, desk research and the expert opinions of the three consortium partners. The indicators were clustered in clearly defined categories during a first work session with the consortium partners. Then the list was further operationalized, by the adding of parameters and descriptions.
Both the definition and the set of indicators were presented to the Ministry of VROM and to several relevant Canadian parties. The results of this first step are listed in Chapter 2.

1.5.2 Selection of the example cities

For the selection of exemplary cities for sustainable urban (re)development policies, various existing ranking lists for sustainable cities were used. At the same time key selection criteria were formulated. These criteria are derived from the chosen definition of sustainable urban (re)development, the wish to see actual progress in the local development and the wish to select somehow comparable examples in Europe and Canada, supplemented with an exemplary American city. This resulted in a longlist of potentially exemplary cities in America, Canada and Europe.
In a joint meeting with the consortium partners, a shortlist of the sample cities was drawn-up, based on the key criteria. The preliminary selection was presented to both the Ministry of VROM and the Canadian parties for a reaction and based on the comments the list was adjusted. The motivated and definitive list of exemplary cities, was reviewed in a second meeting. In this meeting, the consortium partners, together with a representative from VROM, made a last check on the list indicators and parameters to determine and define them more precisely for the next step. A brief description of the motives to select each of the exemplary cities is included in Chapter 2.

1.5.3 Analysing the selected cities

In the next step the selected six cities were assessed on their sustainable quality (physical and spatial quality, socio-economic quality and ecological quality, including resources & mobility flows). The analysis composed from three angels: (1) data and figures, (2) policy context (targets, actions, etc.) and (3) experiences and lessons. The information and trends for the three divisions are based on available public resources and input from policy makers in the selected cities. This analysis on the six selected cities is described in detail in Chapter 3.

1.5.4 The integral approach on policy

From the analyses conclusions were drawn and overall recommendations are formulated for the integral approach of sustainable urban (re)development. The conclusions are supported by graphs. This integral approach on sustainable urban (re)development is discussed in Chapter 4.

2 Definitions and selected cities

In this chapter the definition of sustainable urban (re)development is given, based on existing definitions and the three formulated key concepts, namely, ecologically sustainable, socially liveable and economically healthy. Paragraph 2.2 describes and lists the indicators and operational parameters. Finally a brief background description on the motives for the selection of each of the six cities is given in Paragraph 2.3.

2.1   Definition sustainable urban (re)development

Our definition on sustainable urban (re)development is based on a combination of existing definitions in the broadest sense of sustainable urban development and on the three, self defined, key concepts for sustainable urban (re)development: ecologically sustainable, socially liveable and economically healthy. In Annex A, a selection of definitions on sustainable urban development is included. At the same time the key terms for policy recommendation are derived from the formulated definition. Together with the contractor VROM, the following definition for sustainable urban (re)development is defined and the key words on policy are given:

> **Definition sustainable urban (re)development**
> Sustainable urban (re)development offers a living environment of high spatial, physical and natural quality, where people can develop themselves well, both economically and socially (as to amenities and safety) and where the environment is considered optimally by low emissions (substances, heat and noise), water management, etc. in such a way that the total system is continuable.

This definition forms the framework for the indicators and parameters for the key concept of sustainable urban (re)development and the selection of the example cities.

2.2   Indicators and parameters

The indicators and parameters are composed based on the three key concepts for sustainable urban (re)development (ecologically sustainable, socially liveable and economically healthy) and on ranking list analysis. They are grouped into three qualities; physical and spatial quality, social – economic quality and ecological quality & flows. In Annex B this process is shortly described and illustrated. Also in Annex B a complete summarized table with descriptions and resources of the indicators and parameters per quality cluster can be found. The overview of the indicators and parameters organised by quality cluster is given in Table 1.

Table 1   Overview of the indicators and parameters

Quality cluster	Indicator	Parameter
Physical and spatial quality	Density	- Inhabitants per km^2 - Dwellings per km^2
	Mixed use	- Jobs/housing ratio (neighbourhood/district) - Dispersion of services (schools, grocery stores, restaurants)
	Public green (parks)	- Area of green per inhabitant - Accessibility of green, % of inhabitants living within 500 m of public green
	Urban form	- Typology of building blocks (descriptive indicator) - Grid layout (descriptive indicator)
	Energy efficient buildings	- Number of energy efficient buildings per 100.000 inhabitants
Social-economic quality	Economic quality (prosperity)	- City product per capita - Employment - Distribution of income/average income - Economic stability - Affordability (descriptive indicator) - Demography (descriptive indicator)
	Social quality (well-being)	- Safety (descriptive indicator) - Demography (descriptive indicator) - Citizen participation (descriptive indicator) - Identity (descriptive indicator) - Social equity
	Level of amenities	- Health - Education - Entertainment
Ecological quality & flows	Total GHG emissions (absolute and/or trend)	- Total GHG emissions of at least two years
	Residential GHG emissions (absolute and/or trend)	- Residential GHG emissions of at least two years
	GHG emissions per capita (absolute and/or trend)	- Total GHG emissions of at least two years - Number of Inhabitants
	Solid waste production households (absolute and/or trend)	- Total solid waste production residential sector of at least two years - Number of households
	Recycling percentage of residential waste	- Share of residential waste recycled
	Water consumption per capita (absolute and/or trend)	- Total residential water use of at least two years - Number of inhabitants

Quality cluster	Indicator	Parameter
	Travel mode to work	- Share between travel modes to work
	Air quality trends	- Concentration level of PM_{10} for several years
		- Concentration level of NO_2 for several years
		- Concentration level of O_3 for several years
		- Concentration level of $PM_{2,5}$ for several years

The parameters in *italic* will be qualitative instead of quantitative data.

A summary of the indicators of the three quality clusters is given in Figure 5.

Figure 5   **Summary of the relationship of the indicators**
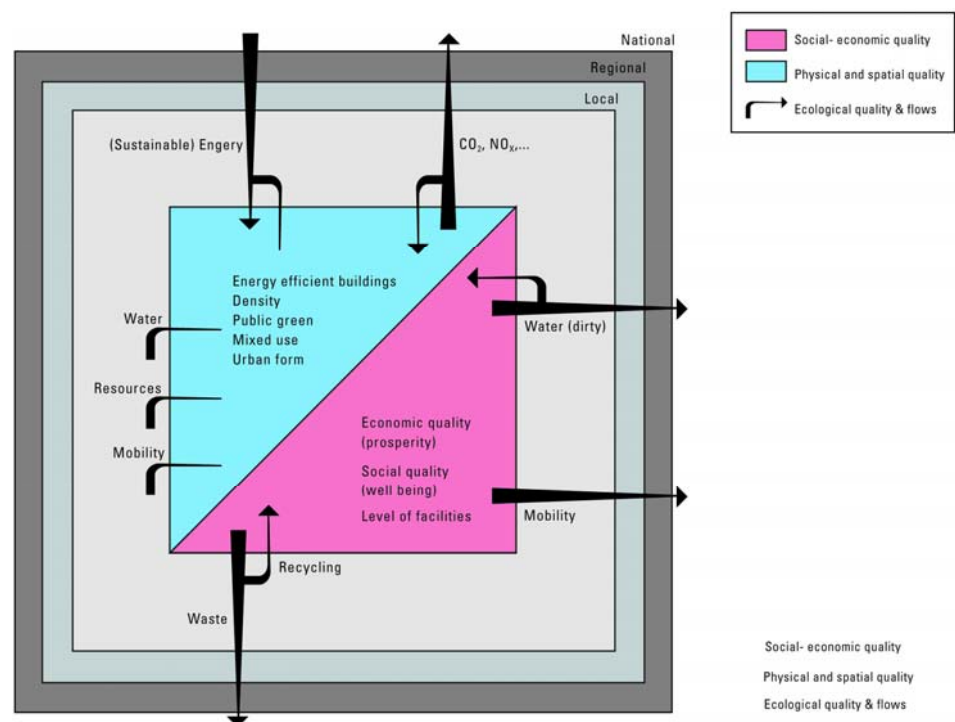
2.3   Selection of the six exemplary cities

For the selection of the example cities we used a "high score" on sustainability of different ranking lists as an initial decisive parameter, the used ranking lists can be found in Annex C. A first selection could be made and formed a longlist of example cities. Together with the formulated key criteria for the selection (see textbox below) we selected six sustainable cities as exemplary cities.

The six selected cities are:

Amsterdam

Amsterdam is the Dutch capital city with sustainable ambitions comparable in size to the foreign cities. It is also the city that is most recognizable for people outside the Netherlands. The bicycle is a very popular way of transport and the city stimulates district heating. Their ambition is to reduce CO_2 emissions by 20% between 2005 and 2015. The vision is to be the first carbon neutral capital in the world by 2025.

Copenhagen

Copenhagen is seen as one of the top class European sustainable cities. The national and local government both have a relatively long tradition of focusing on sustainable development. Almost all buildings are heated with district heating and the use of bicycles is very high. Much urban development is within the city, but still the city keeps its green character. About 80 % of all citizens live at a maximum of 300 meters from a park or recreational area.

Ottawa

The Canadian city of Ottawa has embraced a strong, cross-departmental environmental agenda to improve and preserve Ottawa's environment. The Greenbelt is a 14,950 hectare crescent of land within the present-day boundaries of the city, in which real estate development is strictly controlled. Other priorities are the creation of pleasant transportation corridors, the promotion of cycling and walking and storm water management, which amongst else results in green roof plans.

Rotterdam

The City of Rotterdam improves the climate for the benefit of people, the environment, and the economy. This challenge is embraced by a collective initiative, the "Rotterdam Climate Initiative" (RCI) and includes parties like the Port of Rotterdam and the City of Rotterdam. The ambition is to reduce the CO_2 emission of the built-up area by 50% in 2025 compared with 1990. RCI is part of the international Clinton Climate Initiative. Rotterdam utilises public space and water management to accelerate the envisaged spatial development. To answer the question to what is necessary to deploy public space as an accelerator of spatial development the following key issues have been identified: improving the quality of public space at iconic locations; improving linkages; improving the overall quality of public space; deploying the water management issue to create the desired residential environments.

San Francisco

San Francisco is internationally acclaimed as a sustainable city. It traditionally has a "green" focus. For American standards the city has a high density, is well-known for being walker friendly and has a high use of public transport. It has a prominent position in the field of waste reduction and recycling and local food production and consumption.

Vancouver

Vancouver is a frequently mentioned city in several sustainable listings and is especially famous for its pleasant living environment. The city has about 25 years of experience with co-operation and understanding between public and private parties in shaping the city. Increasing the density (eco-density!), the revival of the city centre and the redevelopment of waterfront sites are focus areas for Vancouver. With these focus points the city can compete with suburbs as an attractive settling place for families. Vancouver profited from the resettlement in their city of prosperous Hong Kong citizens after the return of Hong Kong to China.

The arguments for the selection in summary:
– Two cities in Canada, two in the Netherlands, one in the U.S. and one in Denmark.
– Three cities have about 750,000 inhabitants (Amsterdam, Ottawa and San Francisco).

- Three well-known examples (Vancouver, San Francisco and Copenhagen) versus thee relatively unknown examples (Amsterdam, Rotterdam and Ottawa).
- All cities have a link with water, however not all directly next to the sea (San Francisco, Vancouver and Copenhagen in close proximity to the sea).

Some additional data on the morphology of the cities

Amsterdam is famous for its historic centre with canals forming four concentric half-circles with their ends emerging at the IJ bay. The centre and surrounding neighbourhoods inside the A10 motorway ring road have the highest density. The centre consists mostly of row houses, just outside the canals medium high apartment buildings dominate. High-rise buildings are rare. Outside the A10 ring road, in the west and south east ("Bijlmer") are large neighbourhoods built after Word War II, with characteristic high-rise buildings in a uniform pattern and functional separation.
The latest large-scale expansion of the city is IJburg, a residential area built on several artificial islands in the IJ bay.
From a mono centric city Amsterdam has transformed into a poly nuclear city. Within the city the Zuidas (South Axis) is developed as new business and residential district. A current urban redevelopment area is the banks of the IJ.
The urban and rural land interlocks and is characterized by the metaphor of fingers or wedges.

Copenhagen's medieval centre lays on the border of the Øresund, the strait of water that separates Denmark from Sweden. Outside the city centre the shape of the city is highly determined by the 1949 "Finger Plan" dividing the suburbs into five fingers. The fingers form the suburban built-up area, with a public transport (S-train) connection to the city centre. The wedges between the fingers were kept green and used later on for the construction of highways. The inner-city is surrounded by a ring of apartment buildings. Further, outside the municipality of Copenhagen, one finds suburbs with detached houses.
The city itself is known for its bicycle friendliness with dedicated lanes, paths and routes.
By the opening of the Oresund bridge in 2000 Copenhagen is connected to the Swedish city of Malmö. The construction of this bridge was a boost for the regional development and seen as good practice of polycentric urban development.

Ottawa lies on the border of the Ottawa River and is crossed by the Rideau River. Across the Ottawa River is the City of Gatineau.
Ottawa's current spatial form was highly determined by the 1950 Master plan. This plan designated a Green Belt around the city. Its original purpose included the prevention of urban sprawl (which was threatening the rural areas surrounding the city), as well as to provide open space for the future development of farms, natural areas and government campuses. Although the Green Belt is still in place and conserved, municipalities outside the Green Belt grew heavily. The centre, on the border of the river, is characterized by high-rise office and governmental buildings. Outside this CBD, the city consists mainly of detached or semi-detached houses.

Rotterdam, (originally named after the River the Rotte) lies on the Maas River which is the gateway from the North Sea to the European hinterland. A large part of the municipal territory is taken up by one of the world's largest harbours. The Maas divides the city in a northern and a southern part.
During the World War II a large part of the centre was bombed. The rebuilding was based on modern movement urban design principles. Rotterdam is the Dutch city with the most high-rise buildings. High-rise apartment and office buildings are situated around the central train station as well as on the waterfront on both sides of the central Maas River.
Large areas consist of medium high-rise apartments in closed (courtyard) blocks. As in Amsterdam post-war neighbourhoods like Pendrecht and Hoogvliet are characterized by uniform building patterns, with lots of open space.

San Francisco is part of a large urban area (San Francisco Bay Area) with cities like Oakland and San José. The (administrative) city itself forms a relatively small part of this urban agglomeration, situated on a peninsula surrounded by the Pacific Ocean and the San Francisco Bay.

San Francisco is famous for its hills. There are more than 50 hills within city limits. Nob hill and the financial district form the CBD in the northeast, with high-rise buildings. The further one moves from this centre, the lower the buildings get. A large part of the city is divided in a grid layout, with roads heading east/west and north/south. San Francisco has a lot of parks. The Golden Gate Park and Presidio Park are by far the largest.

Vancouver is located on a peninsula. It lies between Burrard Inlet to the north and the Fraser River to the south. On the west is the Strait of Georgia, it is shielded from the Pacific Ocean by Vancouver Island. Just north of the city start the mountains.

The northern point of the city is Stanley Park, adjacent to this park, the highest densities are found in West End and Downtown. The rest of the city consists mainly of detached and semi-detached or row houses. Most roads are in a grid layout with an east/west and north/south direction.

Figure 6   Morphologies of the six cities
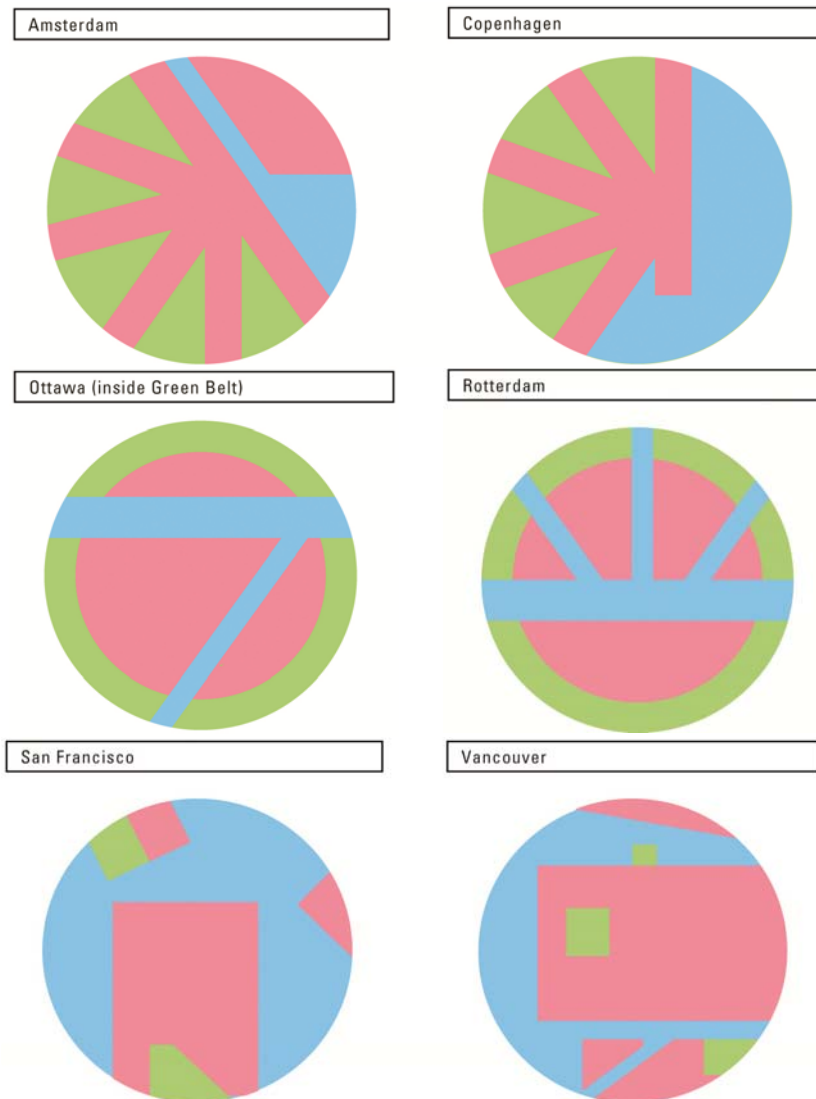
3 Analysis of the six cities

In this chapter we present a selection of the data gathered on the cities of Amsterdam, Copenhagen, Ottawa, Rotterdam, San Francisco and Vancouver. Much more extensive overviews of data are included in the city profiles and policy descriptions in Annex D (separate annex report). We illustrate striking differences and parallels in characteristic figures and try to explain these. For that purpose we briefly describe the relevant policy priorities and initiatives in the six cities. Finally, we draw lessons from the data, experiences and differences for future policy making, anywhere in the world.

3.1   Physical and spatial quality

The spatial form of the city influences the sustainability of the city in different ways. The spatial quality is related to the overall attractiveness of the city for inhabitants, tourists and businesses. Parks, waterfronts and a historic city centre are obvious examples. The urban morphology is the physical aspect determining the "look and feel" of the city. Although each city has a unique morphology, there are generic forms identifiable both on the city and regional scales. Cities traditionally developed along trade routes, often on the banks of a river or in a delta. Water for drinking, sanitation, transport and defence determined the orientation and layout of towns. The growth from towns into cities happened organically or in a planned grid-like fashion. In the last century what used to be the backside of the city has transformed into waterfront locations for top retail and recreational activities.
The unique urban morphology of a city forms the point of departure for sustainable (re)development. The topography, relationship to water and connection to the agrarian hinterland determines the strategies that can be applied for (re)development. The urban form can, for example, be more accommodating to walking, cycling and public transport and thereby potentially lowering pollution, or, the form could accommodate ecological corridors thereby increasing biodiversity and recreative possibilities in the city. The opperationalisation of energy reductions in transport and buildings, more effective water sanitation and reuse, waste management improval and (urban) food production, increasing biodiversity, etc. are all influenced by the urban morphology of the relevant city.
In this section we focus on density, (public) green, mixed use and the smallest unit of the city: the building.

3.1.1   Density and sustainability

Relevance density for sustainability
Density is an intrinsic characteristic of a city; a local concentration of people, jobs, amenities, services is what defines a "city". Nevertheless density is also specifically related to a "sustainable city". It is probably the most determinant factor in the urban morphology's sustainability[2].
Firstly, high density leads to more efficient use of space and helps to avoid urban sprawl and thereby in avoiding externalities like the loss of cropland. Secondly density supports all kinds of services within the city. Public transport, shops, etc. need a certain "mass" to be cost efficient. High densities reduce fossil fuel emissions, as people live closer to where they

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[2]   Note that density is usually expressed - also in this study - in inhabitants or dwellings per area, this does not cover the complete built environment.

work, shop, and spend their spare time. From a social point of view, high density offers more choices for people to fulfil their needs. It increases diversity, safety, vitality and opportunities for creative interaction. It helps to keep the local economy vibrant and healthy.

Figure 7   Indicators density
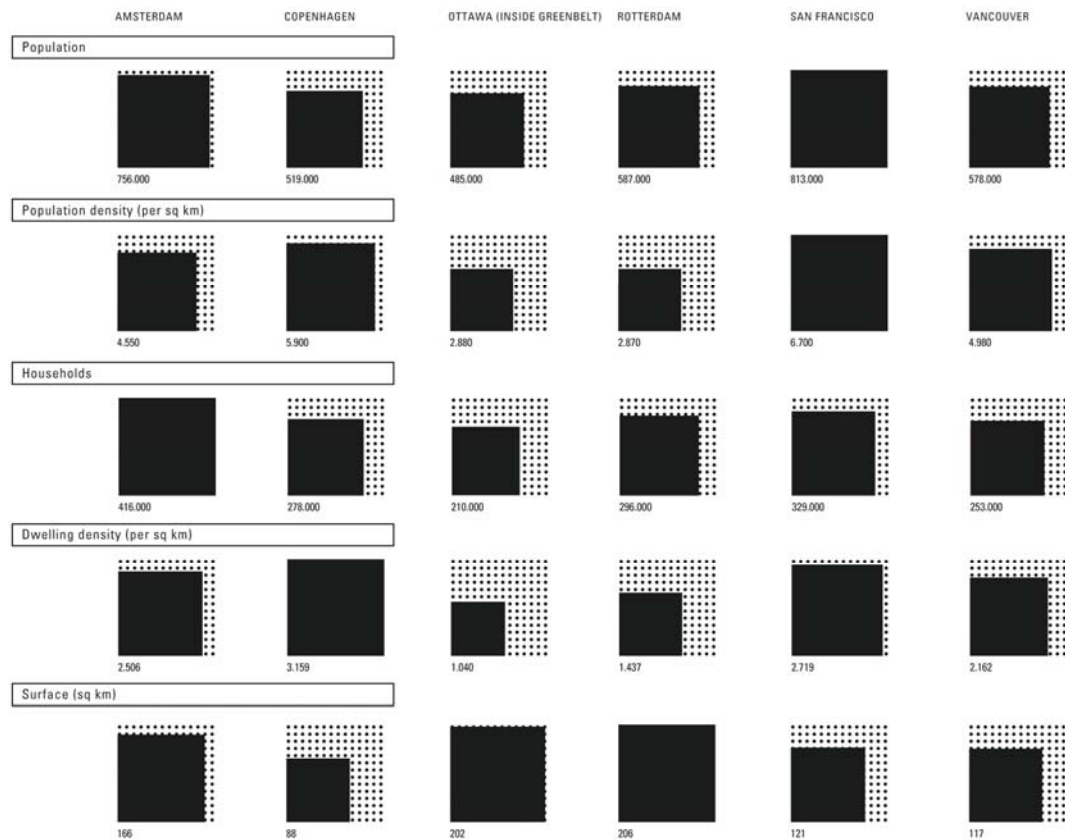
Figure 8   High density area's

Figure 9   Low density area's

■ (pink)	Built-up area
■ (cyan)	Water
■ (green)	Green
□	Paved surface

Amsterdam, Heimansweg, 2.000 km²

Copenhagen, Skippingevej, 600 km²

Ottawa, Johnston Road, 1.800 km²

Rotterdam, Hoofdweg, 1.000 km²

San Francisco, Holloway Ave, 1.700 km²

Vancouver, SW Marine Drive, 2.000 km²
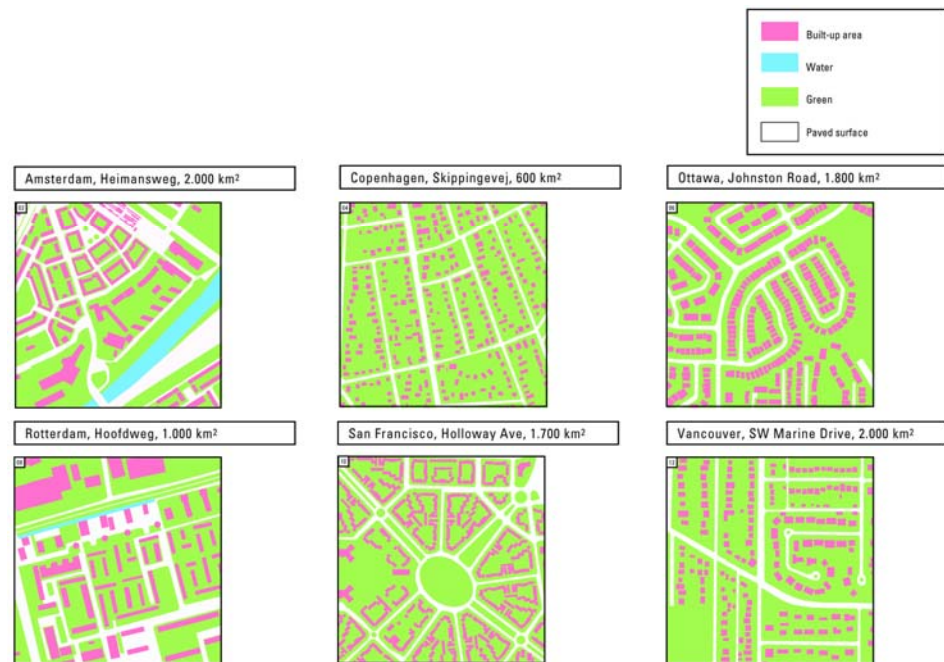
Policy context

In the urban (re)development policy of the City of Vancouver there is a strong linkage between density and sustainable urban development. In advance of the World Urban Forum held in Vancouver in June 2006, Mayor Sam Sullivan launched the EcoDensity concept. Vancouver then made environmental sustainability a primary goal in all city-building decisions[3].

However, density certainly is not the only measure in sustainable (re)development. The potential downside of density is too many people in too little space, which can have negative impact on liveability. Even in Vancouver the EcoDensity concept is not about how many dwellings must be built within the boundary of the city; it is about making an attractive city for its inhabitant's now and in the future and decreasing the city's carbon footprint. Densification in Vancouver is not only about the downtown area with it's high-rise buildings or large-scale brown field redevelopments. EcoDensity is also about densification of suburban areas; e.g. by adding laneway houses (coach houses or units above garages) as "hidden" density or even by "invisible density" such as secondary suites that can fit into an established neighbourhood with minimal or no impact.

In the Netherlands bundling of urbanisation is for several decades part of the national governments spatial policy. The concept was elaborated differently in the past National Spatial Strategies. In the current National Spatial Strategy ("Nota Ruimte" in Dutch) the national government works on the principle of a concentration strategy. This strategy is based on the belief that density supports cities in their function as economic and cultural motors. The goal is to realise 40% of the total expansion programme for houses and employment locations in cities. The national government does not implement the concentration policy itself; that is a task for the local and regional governments.

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[3]   www.vancouver-ecodensity.ca.

Rotterdam wants to develop 80% of all new houses within the existing city limits. The city is facing a migration of well educated citizens to neighbouring (suburban) municipalities. Rotterdam competes with its neighbouring communities; therefore agreements were made to tune the housing program. The centre of Rotterdam and waterfront area are appointed for the demand for urban lifestyle apartments. Other areas within the city should provide in new attractive – "suburban" - neighbourhoods for young families, to limit the suburbanization to the surrounding municipalities.

In Rotterdam's City Vision densification is accompanied by measurements for improving public space and public transport. The combination of solutions for climate adaptation strategies and better neighbourhoods are typical, for example, water squares for better public space, new canals for water retention combined with green and attractive housing and floating homes. The opening of new railway stations for the (inter)national level, improving regional and local public transport (light rail, subway) and Park & Ride facilities at the urban fringe should decrease car use despite of the increasing population.

"Economically strong and Sustainable" and optimal use of space are "business as usual" in Amsterdam's urban planning. The city wants to add 70.000 dwellings by 2040. Hereby explicit attention is paid to the possible downsides of densification. Electric mobility is seen as solution for densification possibilities without extra noise and air pollution. Another issue linked to densification is taking care of absorbing and draining storm water, as densification often leads to an increase of the paved surface.

In their spatial vision both Amsterdam and Rotterdam point out the high cost densification. They both ask the national government to support their investments.

From the six cities included in this research Ottawa is the least densely populated city.

In its Official Plan (2003) Ottawa foresees an ongoing population growth for the next decades. Ottawa's Official Plan directs to "grow in, not out" by concentrating growth within the existing designated urban area. The Official Plan targets for 36% of new dwellings between 2001 and 2011 to be built inside the Greenbelt. In 2006, 23.8% were built inside the Greenbelt. There is (some) local opposition against Ottawa's urban sprawl. In a rally opponents pointed out that sprawl will increase property taxes as providing services and infrastructure to homes located outside the Greenbelt is more costly compared to homes inside the Greenbelt. Also, it is bad for the environment as commuter distances increase. It seems that protests were successful: the elderman decided to withdraw his motion to push urban limits outwards.

Copenhagen sets its ambition in becoming an environmentally friendly metropolis. CO_2 reduction is an important ambition. Densifying the city will make a major contribution in achieving this goal. For example, by developing work areas near stations, employees become less car dependent. This strategy is in harmony with the historic development of Copenhagen. The "Fingerplan" of 1949 has set out the direction of the development of the city along the axes of public transport (and later motorways). During time this plan offered the city a robust concept for its spatial planning as it still guides decisions. Around 80% of new developments occur on brownfields. The remaining greenfield development is compact with excellent public transport connections.

San Francisco continues to grow as a job centre and a transit nexus. To meet local and regional sustainability goals, more housing and greater density is required, but growth needs to be shaped so that it does not occur at the expense of valued San Francisco qualities. Community plans need to balance these factors to increase housing equitably while still preserving what people love about their neighbourhoods.

Besides public transport advantages, San Francisco places densification in a more social context. In the case of smart growth the effort to construct more housing near jobs, and near public transit nodes should also contribute in avoiding unintended consequences on low-income residents. So sustainable development does not focus solely on environmental issues. It needs to encompass the way the city promotes economic growth, so that the most vulnerable, disadvantaged residents get an equal share of the benefits of growth.

Conclusion and policy lessons

Density is widely recognised as an important characteristic of a sustainable city. It is something cities can control well by their zoning or land use plans. In their policy Copenhagen, Rotterdam and Amsterdam focus on large-scale brownfield redevelopment projects like transforming (former) harbour areas into multi-functional urban areas. Vancouver on the other hand emphasizes the possibilities of bottom up small-scale densification. In the latter private, individual entrepreneurship can play a role in making a denser city.

In our exemplary cities, density, design and land use are aligned holistically and comprehensively with other tools and methods for environmental, economic, social and cultural sustainability, to achieve mutual and cumulative benefits. The holistic approach includes transportation, green energy, affordable housing, public realm and community amenities, arts and culture, heritage, health and safety, urban agriculture and local food access, social planning and economic development.

We conclude that compactness and density are important, although not sufficient, characteristics of a sustainable city. In the perspective of Copenhagen's city architect Jan Christiansen is "(...) the exact point at which density becomes sustainable (...) when homes, jobs and day care centres are all within easy reach of one another and when the obvious choice is to use either the bike or public means of transport to reach them"[4]. Densification is used in reducing CO_2 emissions as more people walk, cycle or use public transport. Attention needs to be paid to the downsides of densification, like preservation of open spaces and storm water retention. It is crucial how issues like affordability, liveability and economic vibrancy are dealt with. Public participation and individual entrepreneurship can play role in finding the right balance. Close attention needs to be paid to social aspects and housing demands. Critical is the concept of social equity, which embraces a diversity of values such as housing and working conditions, health, educational services and recreational opportunities and general quality of life. In terms of the housing plan providing affordable housing is an important goal for a sustainable city. Densification should not lead automatically to gentrification.

City administration and planners need to seek a balance between (long-term) profits of intensified density and the interest of the existing local communities.

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[4] http://www.cphx.dk/index.php?id=346336#/346336/

3.1.2 Public green

Relevance of public green for sustainability

Densification requires open (green) spaces in cities. In our study all six cities clearly strive to intensify the use of the city area, so subsequently they have to take care for providing enough open spaces by making new ones and preserving and enhancing the existing ones. Green spaces in a city are not only essential for people's physical and mental well-being. Parks, trees, plants, green infrastructure, etc. clean the air, provide shade, cool the city, collect rainwater and support biodiversity. Green urban areas are the lungs of a city, and as such instrumental in creating a healthy urban environment, especially in relation to the development of a denser city.

Figure 10   Indicators public green (sq m per sq km; % of area)
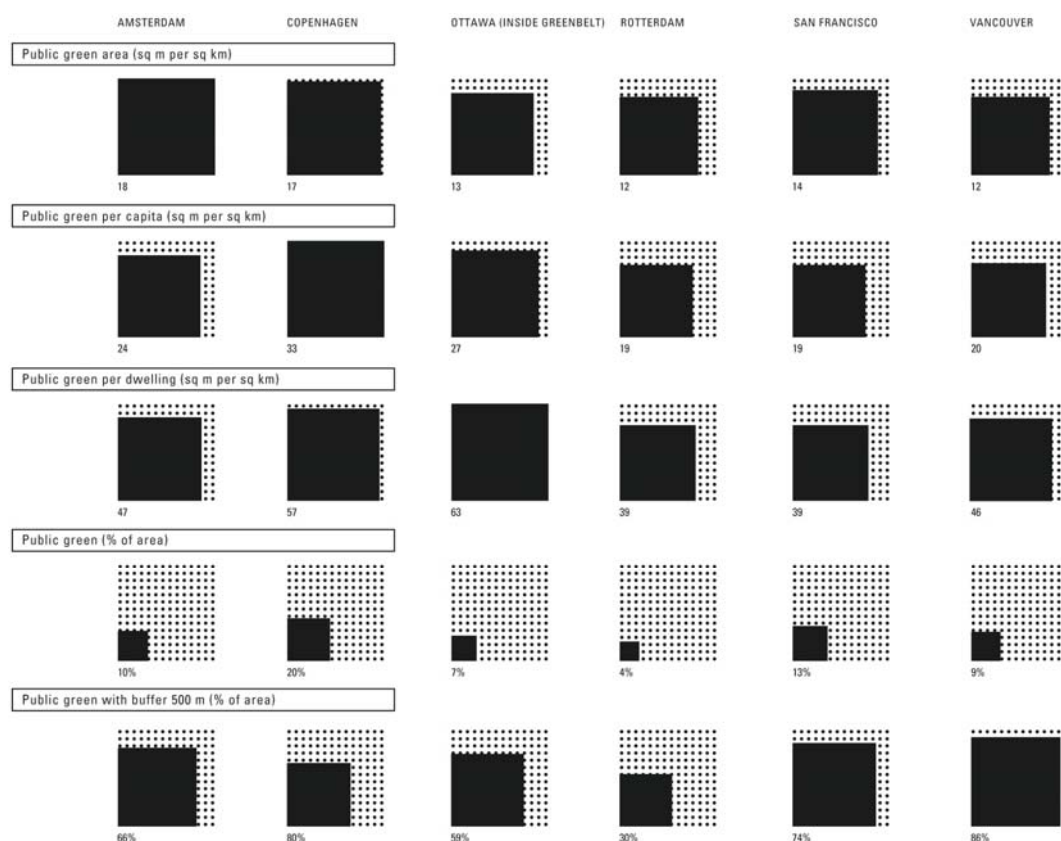
Copenhagen excluding Frederiksberg.
Rotterdam excluding harbours i.e. neighbourhouds "Vondelingenplaats" & "Botlek".

Policy context

The City of Amsterdam recognises that densification will lead to an increased use of parks and public green. A survey among citizens showed that proximity to green is an important condition in choosing where to live or start a company. For each city wedge a master plan will be developed aimed at integration of urban and rural lands at the urban fringe.

One of the objectives of Copenhagen Eco-Metropole (2007) is to increase the percentage of Copenhageners able to walk to a park, a beach or a sea swimming pool in less than 15 minutes from 60 to 90%. A green city includes more than only the parks: the roofs and perhaps also the facades are also taken into consideration. Furthermore a green city has green streets and corridors, utilises surplus areas for green purposes and for sports fields and

playgrounds, and it provides recreational spaces for children and adults alike. Special attention is paid to so called "pocket parks" - part of the Copenhagen Climate Plan - small green spaces for recreational purposes which help cool the city on hot days and absorb rain on wet days.

A high quality "green" space can sometimes be blue. The water quality in Copenhagen is a matter of concern for several years and with success: the water quality in the harbour allows for swimming.

In its Strategic Spatial Plan (2007) the City of Rotterdam chooses the approach of using existing qualities like parks (and also boulevards and monuments) to realise new attractive residential areas. The strategy is to expand existing qualities instead of creating new ones, which spreads out like an oil slick.

San Francisco has a large area of parks. The publicly-owned open spaces make up almost 20% of the city's total land area. San Francisco belongs to the top five cities in the USA in terms of parkland per resident. In addition to the city's strategic spatial vision "General Plan" the Recreation and Open Space Element is the component that provides a 20 year vision and plan for open space in the city. The city wants to increase open space and improve access and connectivity to the parks. Furthermore it wants to protect and improve the ecological value of parks. Engage public participation and pay attention to management for open space acquisition and maintenance. As open space is scarce and pressure on space is high the city started the "Pavement to Parks" project[5]. The project tries to transform wasted spaces mostly found in excessively wide streets into (temporary) plazas and parks. Another initiative focused on small-scale grassroots creation of parks is the "park(ing) day"-initiative. A parking space is temporarily transformed into a pocket park[6]. Another way of dealing with the pressure on space and the need for open spaces is regulated by means of a "density bonus" in the zoning plan. If a developer pays for or constructs open space (there are other also other rewarded developments) he is allowed to build more than the zoning plan actually allows. This system is quite commonly used in cities across the USA.

Vancouver has the intention to create new parks, open space and public places timely and relative to the population levels they serve. The costs for amenities, like parks, are integral part of urban development. Local administration has been extended with an elected Park Board, responsible to maintain, upgrade and expand parks and facilities such as playfields, pools and community centres.

In Ottawa's Greenspace Master Plan Strategies for Ottawa's Urban Greenspaces (2006) the city's public green policy focuses on networks and connection green. Besides the parks the city is surrounded by green areas like the green belt and Gatineau Park.
Urbanization places green areas under pressure. The municipality has a large area within its power after the amalgamation of eleven local municipalities and a regional government in 2001; thereby it has the possibility to control the urban developments within a single government. The city sees this as base for executing its "Greenspaces" Master Plan.

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[5]   http://sfpavementtoparks.sfplanning.org/
[6]   http://www.parkingday.org/

Conclusion and policy lessons

Our conclusion based on the experiences and policy choices of the exemplary cities are that park area and quality should grow along with the city's growth. Parks provide nearby recreational possibilities for citizens and also contribute to the city's ecological health.

The quality expressed in the use, activities, sociability, access, linkage, comfort and image of the existing parks should be optimised, where redesigning can be necessary for serving the needs of changing neighbourhoods. "Linkage" shows it is not only about the parks as "islands" in the city, but attention needs also be paid to routes.

Expanding green areas is costly because of scarce space and pressure from residential and commercial developments. Using land already owned by the city like lands under the freeway, using school yards or assigning allotments a public function as well, are examples of potential interesting areas.

The city's budget is not the only way to finance public green. For instance a Park Improvement District is a public-private partnership in which businesses and/or residents in a defined area pay an additional tax in order to fund improvements and maintenance for the park. Alternatively, let developers pay for green space. The San Francisco park(ing) day movement and "Pavement to Parks" show with creative ideas public space can be made on unexpected places and do not have to sprout only from the town hall. Parks should not only be planned and maintained top down, citizens can play an active role.

3.1.3   Mixed use

Relevance of mixed use for sustainability

Mixed use can be seen as special form of density, namely density in various types of land use. To link mixed use to the cities quality of living goes back to the famous book by Jane Jacobs: *The Death and Life of Great American Cities* (1961). In this book she advocates neighbourhoods with a vivid streetscape. Vivid because people live, work, shop and spend their free time there. Mixed use leads to efficient use of space, reduces the vacancy rate and decay and delivers a sense of security. Moreover, mixed use neighbourhoods are more flexible and can therefore better be adapted to future needs.

Policy context

A way of measuring the mixed use of a certain city is presented by www.walkscore.com. Walk Score calculates the walkability of an address based on the distance from a house to nearby amenities: the more amenities in different categories that are nearby, the better the walk score is. According to the website San Francisco has the most walkable neighbourhoods[7].

A program that supports walkable neighbourhoods is the "Better Neighborhoods Program."[8] Urban neighbourhoods function well when residents can easily meet their daily needs, such as getting to work and shopping. This means having the right neighbourhood mix of housing, retail, open space, and transit, with new housing located near reliable transit lines.

Another San Francisco program is called HOPE (Housing Opportunities for People Everywhere)[9] with the goal of transforming public housing developments from large, disconnected developments into mixed-income, mixed use neighbourhoods. Every public housing unit will be rebuilt within mixed-income developments that include new affordable and market-rate

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[7] Of USA cities. The score can be calculated for any address in city around the world, but the algorithm Walkscore uses relies on Google data which is less accurate outside of the United States/Canada and UK.

[8] http://www.sf-planning.org/index.aspx?page=1699

[9] http://www.sfha.org/hopesf/index.htm

homes, as well as parks and other public amenities for residents and neighbours alike.

An example of large-scale mixed use new urban area is Ørestad in Copenhagen, situated on the Island of Amager southeast of the city centre. Critics stated this new urban development lacked human scale and street life. Although such a large-scale development needs time to become a thriving city district, the city took the criticism into account. One of the improvements was the opening of multi use "park islands" to add city life to the residential and commercial area[10]. The city has learned a lot from the development Ørestad South. In the Carlsberg area in Copenhagen a large, former industrial area will be converted into residential areas, sport and recreational areas and light industry. This is a showcase of a planning strategy that recognises that man is not simply a rational being who wishes to move through life efficiently, smoothly and speedily, but also wants to live a life shared with others in the spaces that the city offers[11]. Mixed use is not about the combination of functions but about the interplay between urban spaces and everyday life.

In the Netherlands mixed use is connected to the challenge cities are facing in the transformation of industrial and business sites into mixed use urban areas. Recently a task force advised the national government - among other things - on improving the quality of business areas by means of mixed use. Regulations on environmental standards on national level should be adapted as they are too rigid and pay too little attention to the overall improvements of the quality of living.

Amsterdam wants to transform business areas into combined business and residential areas. Finding the right mix and dealing with the balance between limiting nuisance for residents and letting companies do their business is the challenge. Both business areas and residential areas can be taken into consideration in search for mixing opportunities. For every new constructed dwelling Amsterdam wants to add five square meters of new small-scaled business units.

The expansion of the port: Maasvlakte 2 creates new opportunities for Rotterdam to expand the city. The "Stadshavens" project aims at making a new urban district where people live and work on former inner-city harbour sites. As mentioned before, the city also wants to build more houses in the city centre as there is a disbalance between residents and workers. In Rotterdam this ratio is 1:3, in Amsterdam it is 1:1. A better balance between residents and workers contributes to a viable and attractive urban living environment in the centre. Additional housing in the centre also supports amenities and activity.

Conclusion

Mixed use is closely related to densification. Every city wants its urban redevelopment areas to be thriving city life districts and taking care of a mixture of houses, commercial space, shop and amenities is the way to go. The ideal refers to the (European) historic city centres, where walking is the natural way of transportation and there is always something happening. It comes down to more than just programming a city, it is about encouraging city life. Flexibility, temporal functions and literary space for private initiatives can act as a motor for achieving this goal. It is about creating a vibe.

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[10] http://www.cphx.dk/index.php?id=344200#/344200/

[11] Freudendal-Pedersen (2009)
http://www.b14cms.dk/users/cphx.dk/files/upload_2/20090910_104612_why_the_sustainable_city.pdf

3.1.4 Physical quality of the built environment

Relevance of physical quality for sustainability

The final subsection of the spatial en physical quality is about the lowest scale we consider in this report: the building. Related to more social aspects of sustainability buildings contribute to the look and feel of the city. Landmarks ("eye catching buildings") give a city appearance and help people to orientate. This subsection focuses on another aspect of buildings, more related to the ecological dimension of sustainability. As buildings account for 72% of electricity consumption, 39% of energy use, 38% of all carbon dioxide (CO_2) emissions and 40% of raw material use,[12] policy for making buildings more energy efficient is an obvious strategy for making a city more sustainable. All six cities have set out policies to improve the energy efficiency of their building stock.

Figure 11   Skylines
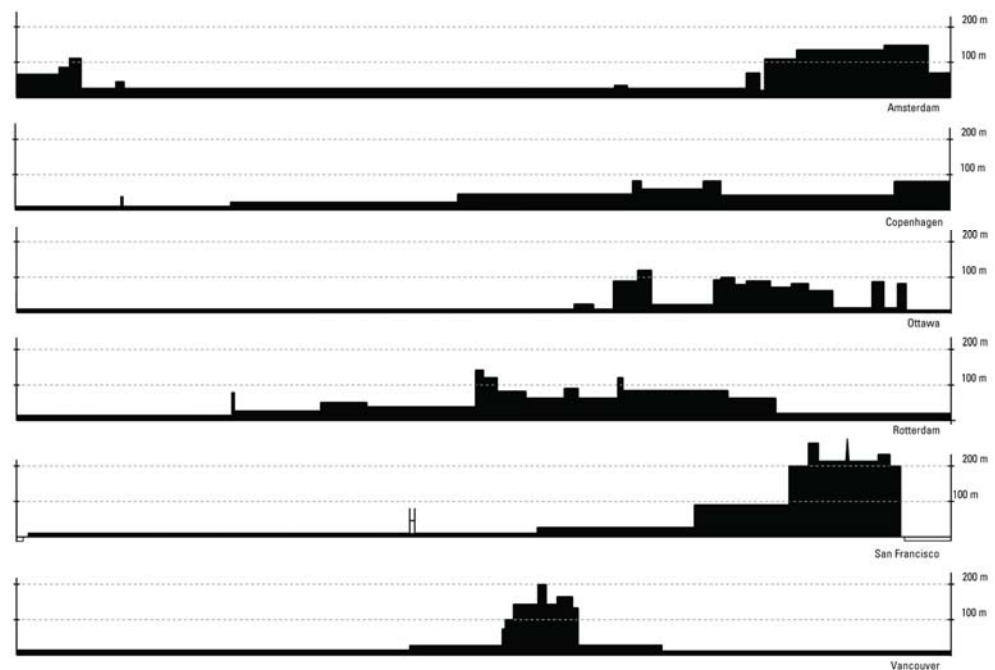
Policy context

The City of Amsterdam has a climate initiative "Nieuw Amsterdams Klimaat" (New Amsterdam Climate). The main targets are that by 2015 all newly constructed buildings have to be carbon neutral, as well as all (new and existing) civic buildings. Newly built houses account for just 1% of the total stock, therefore a lot of effort needs to be put into improving the energy efficiency (retrofitting) of the existing stock. In this regard, Amsterdam is seeking co-operation with the social housing associations.

The Rotterdam Climate initiative has set a target for CO_2 emission reduction of 50% by 2025 in comparison to the 1990 level. This is an ambitious goal considering that the harbour activities account for roughly 20% of the national CO_2 emissions. One of the instruments developed is the Rotterdam Energy Approach (REAP, Tillie et al 2009), to consider energy and CO_2 reduction in an early planning stage. Energy and CO_2 have become a "layer" in urban planning.

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[12]   United States Green Building Council, USA figures
(http://www.usgbc.org/DisplayPage.aspx?CMSPageID=1718).

The step from the level of the building to neighbourhoods and the entire city is made.

As all new buildings in the Netherlands, new buildings in both Amsterdam and Rotterdam need to meet the national building standards and additional requirements on energy efficiency EPC (energy performance coefficient). This ensures the energy efficiency performance of all new Dutch buildings is comparable to (at least) the LEED certified standard, used in the USA and Canada[13].

In Copenhagen new buildings are also influenced by strict national rules on energy efficiency. Besides these regulations the city has a mixed policy of providing information on home improvements and as a municipality setting a good example of high standards for all public buildings both in new buildings as in renovation projects. All measurements are part of the Copenhagen Climate Plan (2009). An important role in the energy efficiency plays the Copenhagen district heating system as its supplies 97% of the city with clean heating.

San Francisco has a Green Building Ordinance (2008). Requirements in the ordinance for new buildings contribute to the goal of reducing the greenhouse gas emissions in the City and County of San Francisco to 20% below 1990 levels by the year 2012. In time buildings have to met higher (LEED and other) standards. Projects that commit to LEED Gold certification are eligible for priority in permit processing through coordination with the Planning Department, Department of Building Inspection, and Department of Public Works.

The City of Vancouver is actively incorporating green building objectives and standards into the Vancouver Building By-law (VBBL). The Green Homes Program addresses energy and water efficiency issues by requiring that all new building permit applications for one and two family homes meet a specific set of requirements. The most significant energy users are the existing buildings. Permits for renovation are tested on energy increasing the buildings energy performance. All new civic buildings in Vancouver are required to meet green building standards known as Leadership in Energy and Environmental Design (LEED) at the Gold level. It is discussed to make this standard applicable for all new buildings. The development at Southeast False Creek (Olympic Village) is used as a statement about the direction of future development in Vancouver and will be a model sustainable community for the world. All buildings required a minimum LEED Silver equivalent.

Improving the energy efficiency of buildings is part of Ottawa's "Air Quality and Climate Change Management Plan" (2003). Besides greening the municipal buildings the city seeks to stimulate private investors like citizens to improve their houses. For instance by informing citizens on cost-effective ways to make homes more energy-efficient. An interesting concept is the use of Local Improvement Charges (LIC). The municipality lends the property owner the money for the energy efficiency improvements and collect the interest through the tax bill with the payments set slightly below the actual energy savings. The charge is attached to the property, not to the owner.
This latter point is interesting because investments in energy efficient techniques have their revenue on the long-term, maybe longer than a resident

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[13] Compared on energy efficiency as use of energy and material is only considered in the Dutch system. LEED has a broader scope and takes also for instance green roof tops, public green and bicycle parking in account. The Dutch Green Building Council (www.dgbc.nl) developed a sustainability label based on the English BREEAM methodology which has takes more than solely energy in account.

is planning to live in the same house which could negatively influence an investment decision.

Conclusion and policy lessons
We conclude that the cities can, in their building ordinance, influence the energy efficiency of newly constructed buildings. As new buildings represent only a small percentage of the total amount of buildings, much profit can be made by the retrofitting of existing stock. When applying for a renovation permit energy efficiency demands can be stimulated by the municipality. Much can be gained when alliances are made between local authorities and large institutional home owners like social housing associations. The municipality set a good example when building new or renovating civic buildings. In so doing, business cases can be proved.

Energy is not something that should be examined on the building scale only. REAP shows that by balancing energy waste flows like heat between buildings, up to 80% reductions can be achieved. The step from individual buildings to clusters of buildings, neighbourhoods, districts and even entire cities can turn existing areas into carbon neutral areas.

CO_2 neutral buildings and the superlative degree of complete new CO_2 neutral cities like Dongtan and Masdar gain a lot of attention which is understandable as they show the state of the art in sustainable design. But the largest profit is to be gained in the already existing built-up areas of cities, simply because there is so much more of it. Examples of cities which successfully improve the existing stock deserve attention. The sum of probably less visible actions might be not as "glamorous" as new buildings but the effect in terms of CO_2 reduction is much larger.

3.2   Socio-economic quality

The social economic quality of the city alludes to the different aspects that are contributing and influencing the economic and the social well-being of the citizens. The fact that social economic quality is the result of how different factors are interrelated, makes it hard to measure with one specific indicator and can be different in every situation. However, in this section we will highlight some aspects on the social-economic quality of sustainable cities, subdivided into economic quality, social quality and level of amenities.

3.2.1   Economic quality of sustainable cities
The economic quality of a city is subject to macro-economic developments, for example the financial crisis that affects the world's economy but even so the current ecological crisis (the decline of biodiversity and the depletion of resources). A sustainable economy is in a continuous state of change and adapts successfully to these factors. Making the right decisions creates a stable situation for the citizens to live and work in.

In Amsterdam it is the economic diversity (financial and business services; IT; creative industry; life sciences; trade and logistics; tourism and congresses; food, fish and flowers) that forms the economic strength of the city. The open attitude to new things (as well economic as cultural) is due to the fact that Amsterdam is one of the world's capitals on information technology (IT). The creative class plays an important role in the ongoing renewal of the Amsterdam economy.
Amsterdam has different initiatives for "greening" her economy. Amsterdam for example aspires to become the leading wind and sun energy city of the Netherlands and wants to supply one third of their energy needs by locally

produced sustainable energy by 2025. In order to be able to realize this ambition Amsterdam investigates for example the feasibility of raising a "sustainable energy" enterprise that will invest in sustainable energy production within the City of Amsterdam. This municipal enterprise will in co-operation with businesses and housing associations invest in photo-voltaic, wind-energy and in the construction and transition to a "smart electricity grid".

In Copenhagen life science, information technology and shipping are important sectors and research & development plays a major role in the city's economy. Ottawa, besides offering a lot of government related employment, has a main high-tech development sector. Ottawa has become known as "Silicon Valley North". In 2020, Ottawa will be a prosperous, entrepreneurial and globally competitive city fuelled by an agile economy that is expert in managing change and reflects the values of innovation, equity and environmental stewardship, thus the ambitions of the city.

Rotterdam's economy is mainly driven by her port and industry, medical sector and creative industry. The highly developed medical sector, which employs both high and low educated people is an important completion to the other sectors, like port and industry that are more sensitive to economic rupture. Rotterdam intends to develop into a Clean Tech Delta city, with a Climate Campus in the Stadshavens area (a vast former inner-city harbour area). Rotterdam also shows an inspiring case called Rotterdam Cirkelstad, an initiative in which the City of Rotterdam cooperates with several Rotterdam companies in the construction sector. The aim of this initiative is realizing high-grade re-use of materials that come from demolition. Re-usable materials are extracted from the buildings that are to be demolished and offered as raw material for construction, preferably on the same site.

San Francisco is a main global financial centre. Other sectors are trade and shipping, new media and innovative new technology.

Vancouver - The economy of Vancouver is dominated by trade and port, other main economic sectors include, trade, film, natural resources, technology and tourism. To become the greenest city in the world Vancouver wants to be in the long-term the Mecca of green enterprises. To reach this goal Vancouver wants to create 2000 green jobs each year until 2020. Vancouver sees the following steps: first, the creation of Low-Carbon Economic Development Zones and secondly a green entrepreneur kick-start program. Low-Carbon Economic Development Zones, featuring green infrastructure and a variety of financial incentives, will enable the City to attract businesses that anticipate a carbon constrained world. The green entrepreneur kick-start program would provide financial assistance, management support, and expert mentoring for aspiring entrepreneurs with bright green business ideas. Capitalizing on these ideas will give Vancouver a leg up on other cities in the race for environmental sustainability.

3.2.2 Social quality of the cities

During the last 50 years the main goal in city planning has been creating efficient and easy accessible cities. These planning strategies have had a large number of unintended consequences with impact on the social life of cities. Consequently, social sustainability becomes more and more important.

A city is composed of people as well as the places where they live; it is as much a social environment as a physical environment. In creating sustainable cities and communities, citizen participation becomes of great importance since maintaining and supporting sustainability needs the engagement of people. The following examples show the wide scope that citizen participation and social cohesion is about (DAC, 2007)

Amsterdam has the GWL terrain as a strong example of citizen participation in city planning. Their participation resulted in an oasis-like green living environment with a strong social cohesion in a high dense environment. At the start of the project high sustainable ambitions were set. The most extreme was that cars were forbidden. Although we nowadays say that this is an odd decision, because we are common to organize our cities around cars, the case of GWL terrain shows us that prohibiting cars created space for a strong social cohesion by realizing a lot of green spaces in the neighbourhood, in the form of vegetable gardens and public green. Because of these characteristics this part of Amsterdam is still - ten years later - a very popular high-density neighbourhood to live in.

The City of Amsterdam is famous for her authentic monumental inner-city and art collection. She actively cares for this treasure. This wonderful asset simultaneously causes numerous problems, mostly relating to mobility and energy consumption of the historical buildings. The policy of the city is handling these problems for years and it seems that sustainability can bring some solutions that are enhancing the qualities of the inner-city. In this way Amsterdam has one of the best developed car-share networks of the Dutch cities, reducing the number of cars in the inner-city, thereby stimulating a more effective use of the present cars and creating more free parking places. At the moment there is an active policy on warding dirty vehicles from downtown Amsterdam and a stimulation of all kinds of electric vehicles by means of financial incentives. Public transit is organized efficiently and at different scales. From fast metro connections to bicycle taxis. A huge investment in the North-South underground will make the new South Axis business district (Zuid-as) more accessible.

The Copenhagen Wheel is an electric "hybrid" bicycle that is also a smart mobile sensing device that can map real-time flows and environmental conditions in cities. The sensors integrated in the bicycle provide location and environmental information (CO, NO_x, noise, temperature and humidity). By collecting this data the City of Copenhagen will be able to improve the cities network of cycling paths, discover obstructions and map the air quality throughout the city. The traveller can track his own mode of cycling by his smart phone.

Copenhagen is often called the worlds #1 bicycle city, while Amsterdam also achieves well in this regard. Copenhagen though, is much more active in improving their system of cycle lanes and increasing the amount of cyclists in order to reduce CO_2 emissions. This biker-friendliness plays a big role in the marketing of a healthy and sustainable Copenhagen.

Rotterdam - "Opzoomeren" is the verb that generated from a residents initiative to refurbish the "Opzoomerstraat" in 1981 all by themselves. It appeared to help increase the social cohesion among the residents of that particular street. This approach gained a lot of media attention and was repeated in different streets numerous times. At the moment it is still a satisfying way of improving social cohesion (in Rotterdam 50% of the population is of non Dutch origin). Some examples of Opzoomer-activities are street dinners, cleaning up the street, kids games or adjusting street lighting for a safer environment.

The City of Rotterdam promotes itself as a delta city, with a long history of living with water. Inline with her experience in this field, the region is one of the worlds leading knowledge centres on sustainable water management, dredging, coastal protection, etc.

Vancouver - The Placemaking Project in Vancouver Glenville Island is a first-class example of how a great district can emerge, even in the most unlikely location, because local people identified the area's unique potential and worked hard to create vital public spaces. The island's status as one of Vancouverites' favourite spots isn't due to some ingenious stroke of master planning, but to the steady, patient progress of local organizations and businesses (PPS, 2004)

3.2.3 Level of amenities

Social and physical health of the citizen should be the goal of a sustainable city by implementing and influencing the level and quality of the amenities that is offered.

Social health is reached by providing employment, affordable living, safe neighbourhoods, citizen participation, entertainment, community building and vibrant and attractive public spaces.

Physical health will be reached by providing a healthy and safe living environment, healthy food, affordable healthcare and healthy transport.

Both Vancouver and Copenhagen appoint the physical health of the citizen as one of their goals. Social health of the citizen and community is less strongly related to sustainability and thus not translated to policy and actions.

The focus of Copenhagen on facilitating health and well-being is closely related to the means of transport. Data collected by the city shows that despite the increase in the amount of cyclists, the number of accidents and severe injuries are steadily diminishing, due to improvements of the cycle lanes and routes. The research also shows that the perceived safety of cycling in Copenhagen depends whether the persons are actually cyclists themselves, non-cyclists perceive it as dangerous, regular cyclists as "not without risks" and continuous cyclists perceive it as a safe mode of transport. By providing healthy public spaces like the city's popular parks, beaches and sea swimming pools, the Copenhagen case proves that a good environment enhances peoples' daily well-being.

Overall, we can state that the level of amenities in each city is high and differs to the nature of city formed through time, geographic situation, culture and climate. Vancouver offers a variety of nature related recreation facilities, like fishing, skiing, mountaineering, etc. for it is locked in between the Rocky Mountains and the Pacific.

Amsterdam for example offers a large variety of cultural entertainment, like museums, theatre and music as well as an amazing monumental inner-city, which is a pleasure to stroll through and a real tourist magnet.

Finally, we recognize a small but increasing concern amongst the cities regarding the promotion of local food and the development of urban agriculture. In the City of Vancouver a program has been launched to increase the use of regional food to lower CO_2 emissions, it simultaneously diminishes the cities dependency on the world's total food supply. Besides this, Vancouver aspires to become the leading city with respect to urban agriculture by 2020.

3.3 Ecological quality

This section focuses on the ecological sustainability of the six reviewed cities and on the policies that seem to yield effect in these cities. In our analyses we consider the ecological sustainability to be primarily reflected by energy consumption levels, waste volumes, traffic flows and water consumption and by the related emissions of greenhouse gasses, hazardous substances and noise. Additionally we also look at the policy attention for the total life cycle and for a long-term environmental vision in the cities and at their self provision level (energy, water, food).

3.3.1 Consumption and emission data

Figure 12 indicates the volume of the residential green house gas emission per household in the six cities in tonnes per citizen per year. The table also indicates whether the emissions have been increasing or decreasing over the last couple of years. The overall picture aligns quite well with the data we could trace on the use of energy in the six cities. Particularly the City of San Francisco shows a rather high emission figure, but this city also shows the highest reduction speed.

Figure 12   Indicator total residential GHG emissions (ton per citizen per year)
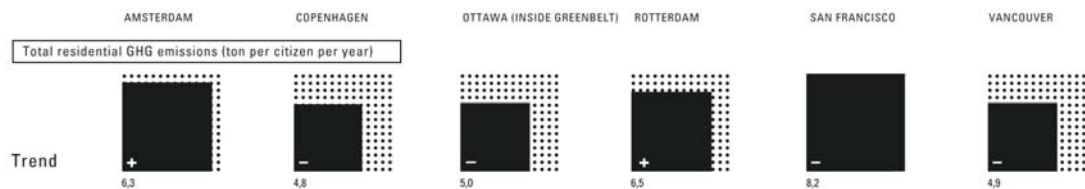
We see an overall increase in the emissions per citizen in the cities of Amsterdam and Rotterdam. This might be explained by the increasing number of small households, an increasing number of electrical appliances and an increase in comfort standards. On the other hand we see a decrease in the use of energy per citizen in the cities of Copenhagen, San Francisco and Vancouver. In these cases the local energy and environmental policies seem to yield effect, since these cities are also confronted with smaller households, more appliances and higher comfort standards.

Figure 13 indicates the volume of solid waste per citizen in the six cities and the percentage of recycling or other re-use (between brackets), again with a trend indication.

Figure 13   Indicator total solid waste production per citizen (kg per year and percentage of recycling)

	AMSTERDAM	COPENHAGEN	OTTAWA (INSIDE GREENBELT)	ROTTERDAM	SAN FRANCISCO	VANCOUVER
Total solid waste production per citizen (kg per year)						
Trend	≈	—	N/A	N/A	—	—
	482	433	310	567	740	594

	AMSTERDAM	COPENHAGEN	OTTAWA (INSIDE GREENBELT)	ROTTERDAM	SAN FRANCISCO	VANCOUVER
% Recycling						
	21%	27%	32%	33%	72%	55%
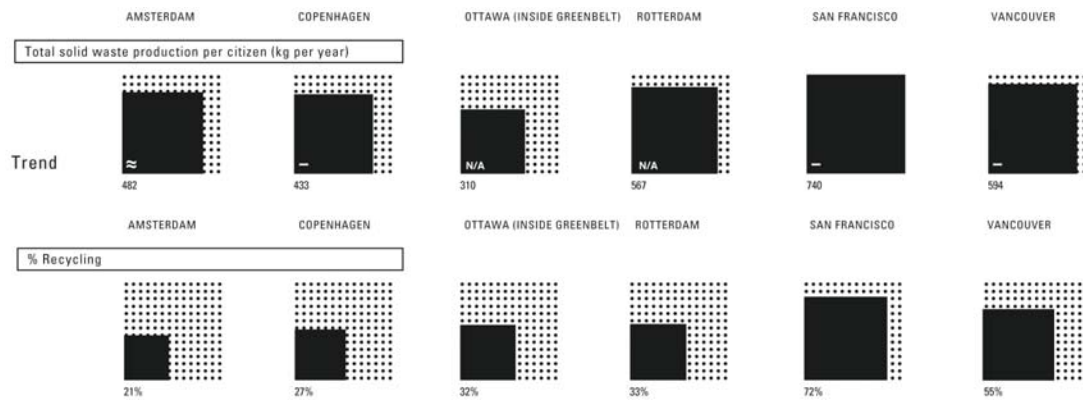
Here again the figure is the highest for the City of San Francisco, but also this city shows the best results in decreasing the yearly production of solid waste per citizen. San Francisco also has the best percentage for recycling of waste materials.

Figure 14 shows the water consumption, with again the trend indicated. Overall the picture aligns quite well with the data on the use of energy. No data is available for the City of Rotterdam at this stage.

Figure 14   Indicator water consumption per capita (litres per day per citizen)

	AMSTERDAM	COPENHAGEN	OTTAWA (INSIDE GREENBELT)	ROTTERDAM	SAN FRANCISCO	VANCOUVER
Water consumption per capita (litres per day per citizen)						
Trend	≈	—	—	N/A	≈	≈
	172	114	340	124	259	448

We do not have an adequate explanation for the huge difference in water consumption between the European cities and particularly the Canadian cities. It might be due to the gardens and the swimming pools in.

In the project also data was gathered for other indicators like air quality, traffic modalities, etc. The data obtained are included in the annexes, but are too incomplete or fragmented to compare the cities or to draw conclusions.
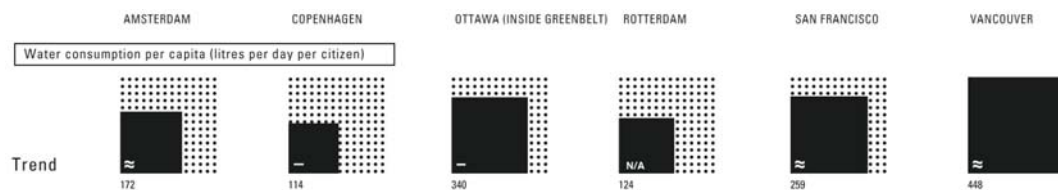
3.3.2   Policy context

All cities have drawn-up environmental policies which influence the use of energy and water, waste flows, etc. However, the main policy intention behind the policies is quite different. In the three European cities green house gas emission reduction is the primary target. In Ottawa conservation and protection of green areas is the primary aim and in Vancouver the creation of new (green) jobs. In San Francisco there is not one leading principle.

Another interesting difference is that the policies in the latter three cities cover a wide, if not the full, scope of the sustainability field. Ecological sustainability for these cities is an element of a wider sustainability approach, where policy instruments have been developed in a more or less parallel way for all tracks within the approach. In the European cities the total approach currently particularly focuses on the ecological track. Rotterdam is the strongest example in this respect, where the Rotterdam Climate Initiative fully

started from this track and other elements of sustainability where included in the approach at a later stage. Copenhagen, on the other hand, started from a wider sustainability approach but is particularly focussing on the ecological track during the last years. In Amsterdam the situation lies in between. The differences are illustrated in Figure 15.

From all policy approaches the schemes in Amsterdam and Copenhagen are the most directly aimed at energy; in Amsterdam particularly through energy conservation in all societal sectors and renewable energy, in Copenhagen through heat grids and also renewables. The different approaches so far do not lead to clear differences in the amount of energy used per household. However they seem to result in differences in the consumption trends over the last couple of years.

Figure 15   Sustainable approach of the six example cities
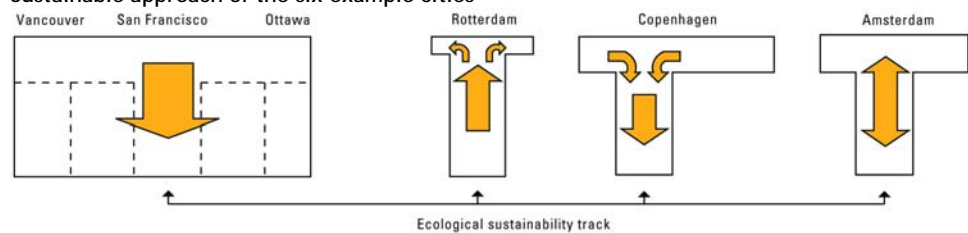
The policy analyses also reveal that the Canadian and US cities have substantially more individual statutory authority for the implementation of policy measures than the European cities. The cities of Amsterdam, Copenhagen en Rotterdam have to depend in much more situations on national or European directives and regulations. They are also bound to or even limited by these regulations in their actions.

An important example in this respect is the City of Rotterdam. 90% of the energy consumption and GHG emission in this city take place in the huge harbour industrial complex. Apart from some options in the sphere of information and voluntary agreements for example, the city depends on national and European regulations for its policy approach of the industrial sector and on the willingness of the international managements of the multinational organisations.

The City of Amsterdam has been working on concrete technical measures to improve energy efficiency in all its societal sectors. The municipality plays an exemplary role and it actively looks for co-operations with other stakeholders. Long-term consistency is an important characteristic of the Amsterdam policy. Hydrogen is used, as a pilot project, in the city centre busses, municipal vehicles and tourist canal boats. The local Energy & Waste Company (AEB) generates electricity from waste. The district heating grid, which AEB and other plants supply with residual heat, will be expanded. The policy ambitions of the City of Amsterdam exceed the Dutch national ambitions in many aspects.

The City of Copenhagen actively promotes cycling through investments in bicycle paths, cycle routes and even new bridges. The city also actively promotes the greening of fuel sources for power plants and CHP plants, for example by geothermal energy. Like the rest of Denmark the city also promotes the application of wind energy. Policy making in Copenhagen over the last decades has been characterised by constant modernisation and new target setting. Like the majority of large European cities, Copenhagen has

difficulty in living up to the air quality requirements for nitrous dioxide (NO_2) and large particles (PM_{10}). An environmental zone has been created with congestion charging and environmentally friendly vehicles. Also, in this respect, the municipality wants to go further than the law currently allows. National and international limits ensuring improved air quality should be tightened.

First priority in the sustainable urban development strategy of Ottawa is the conservation and protection of residential green spaces. Other priorities are the creation of pleasant transportation corridors, to promote cycling and walking, and storm water management, which amongst else results in green roof plans. Attention for environmental factors and costs is fully incorporated in the City decision-making processes. For all new developments an environmental impact statements (EIS) is required. The developments should in no way harm the green spaces or human health and resources should be used as efficiently and effectively as possible. The intention of the city is to "grow in, not out". With respect to energy the city offers and facilitates an energy audit system.

In the City of Rotterdam the local policy targets for renewable energy are fully in line with the national Dutch targets. However, policies for energy efficiency are higher as well as the target for local CO_2 emission reduction strongly exceeds the national target, both in volume and in realisation speed. This ambition is motivated by the economic chances it will offer to the Rotterdam harbour area, both as a consequence of new business opportunities and by the possibility for further growth (which would otherwise be hindered). In 2009 the Clean Tech Delta was introduced as an umbrella term for the ambitions of the city(region) in its transition from a fossil to a renewable economy. The inner-city harbour area (Stadshavens) has been declared a living laboratory for experimentation in sustainable innovation in the built environment and also in terms of urban policy. By lowering the norms and regulations for parts of the area the government is facilitating experimentation and innovation.

The City of San Francisco has an Electricity Resource Plan which includes the implementation of energy efficiency programs, development of renewable energy resources such as wind and solar power and energy self-reliance. The ERP is part of a wider Climate Action Plan, which describes what San Francisco can do to achieve its stated goals, improved air quality and reduction of greenhouse gases by 20% below the 1990 levels.
The city is also active in the stimulation of car-pooling and public transport. It has mandatory rules for composting and for the recycling of materials, plastic bags are forbidden in groceries and supermarkets, for example. The city also has mandatory rules for the LEED certification of commercial and residential buildings above a certain size.

Vancouver sees working on the environment as an excellent opportunity to create new business activities and jobs. The main targets for the city are the creation of about 20.000 new jobs, clean air and accessible and safe streets. The city intends to reach this by realising green buildings, new infrastructures for walking, cycling, and public transit and local production of food. An additional target is eco-density. Issues like energy efficiency, the use of renewables, improvement of air quality, waste reduction are circumstantial targets. For most measures the city has adequate power to implement and execute the required actions. However, the city lacks the statutory authority to enforce, for example, a ban on the use of certain materials like plastic bags and polystyrene foam.

Figure 16   Summarising overview of policy angle differences for the six exemplary cities

	Obligation approach	Stimulation approach
Full scope of sustainability	San Francisco / Vancouver	Ottawa
Primarily climate angle	Copenhagen	Amsterdam / Rotterdam

3.3.3   Lessons for future policies

Based on the policies and the experiences in the six exemplary cities some general observations on the effectiveness of policy instruments can be made.

A first general lesson is that the effectiveness of policy measures in the area of energy and ecology is strongly interrelated with the level of ambition on the other aspects of sustainable urban development. The approaches in Vancouver and Copenhagen, and to a certain extend also in Rotterdam, clearly show that socio-economic growth might well go hand in hand with energy efficiency and implementation of cleaner technology. However, we must realise that this observation might be a consequence of the selection of six cities that are doing relatively well.

Another lesson is that central leadership, enthusiasm and directorship are important success factors for the realisation of energy and environmental policies. The approaches in Amsterdam, Copenhagen and Vancouver show obvious examples of this effect.

Good results can be realised by approaches that create conditions and stimulate people, like the successful cycle lanes and public transport systems in different cities. However, this type of approach does not yield sufficient results in other areas and for other groups of people. This is one of the reasons that several of the exemplary cities tend towards a more mandatory approach, aimed at the more difficult dossiers and those who lag behind.

Particularly in this field co-operation at regional, federal or even international level is required. This is a complex matter for individual municipalities and it requires a lot of effort, but it also potentially yields the most significant results.

4 Conclusions & recommendations

In this report we have compared the sustainable urban development policies, strategies and results in the cities of Amsterdam, Copenhagen, Ottawa, Rotterdam, San Francisco and Vancouver. One of the reasons to specifically select these six cities stems from the fact that the project was executed in the framework of a Memorandum of Understanding between Canada and the Netherlands. Consequently we wanted to include two cities from both countries, complemented with one extra city on both sides of the Atlantic Ocean. Another reason to select these cities is that they are considered to be exemplary front runners with respect to sustainable urban development, with both relevant experience and interesting topical developments.

In this section we do not intend to rank or to benchmark the cities in any way. On the contrary, we simply compare characteristics to trace relationships between specific actions and effects and try to learn from both the differences and parallels in the approaches and from the results that have been achieved. We elaborate on specific types of action that seem to be extra effective and we illustrate these initiatives with practical examples. Based on the policies, strategies and experiences in the six cities we draw a series of conclusions on the effectiveness of policy instruments and come up with recommendations for local and national policy making with respect to sustainable urban (re)development.

4.1 Policy characteristics and results

We start with an overview of the policy attention that is given in each of the cities, as part of their urban sustainability policy, to a range of eleven issues that are related to the sustainability of the city. The level of attention for these issues is depicted in six "spider webs" which offer a compact overview of the city policy focal areas. Below each spider web the scores of the cities on the three studied fields of sustainability (spatial quality, socio-economic quality and ecological quality) are given.

Since there are no objective criteria to assess the cities the scores are based on the material that was studied, the contacts that have taken place and the expert opinion of the researchers. However, we fully realise that this is to a high extent a limited and subjective judgement, which is not intended or suited to benchmark the cities. The scores on the different indicators now reflect whether (a) the issue is mentioned in policy documents, (b) ambitious targets and concrete measures are defined, (c) the measures are implemented, (d) there is a long-term vision behind the actions and (e) there is an integrated inter-disciplinary policy approach.

Figure 17   Overview policy character for the six cities
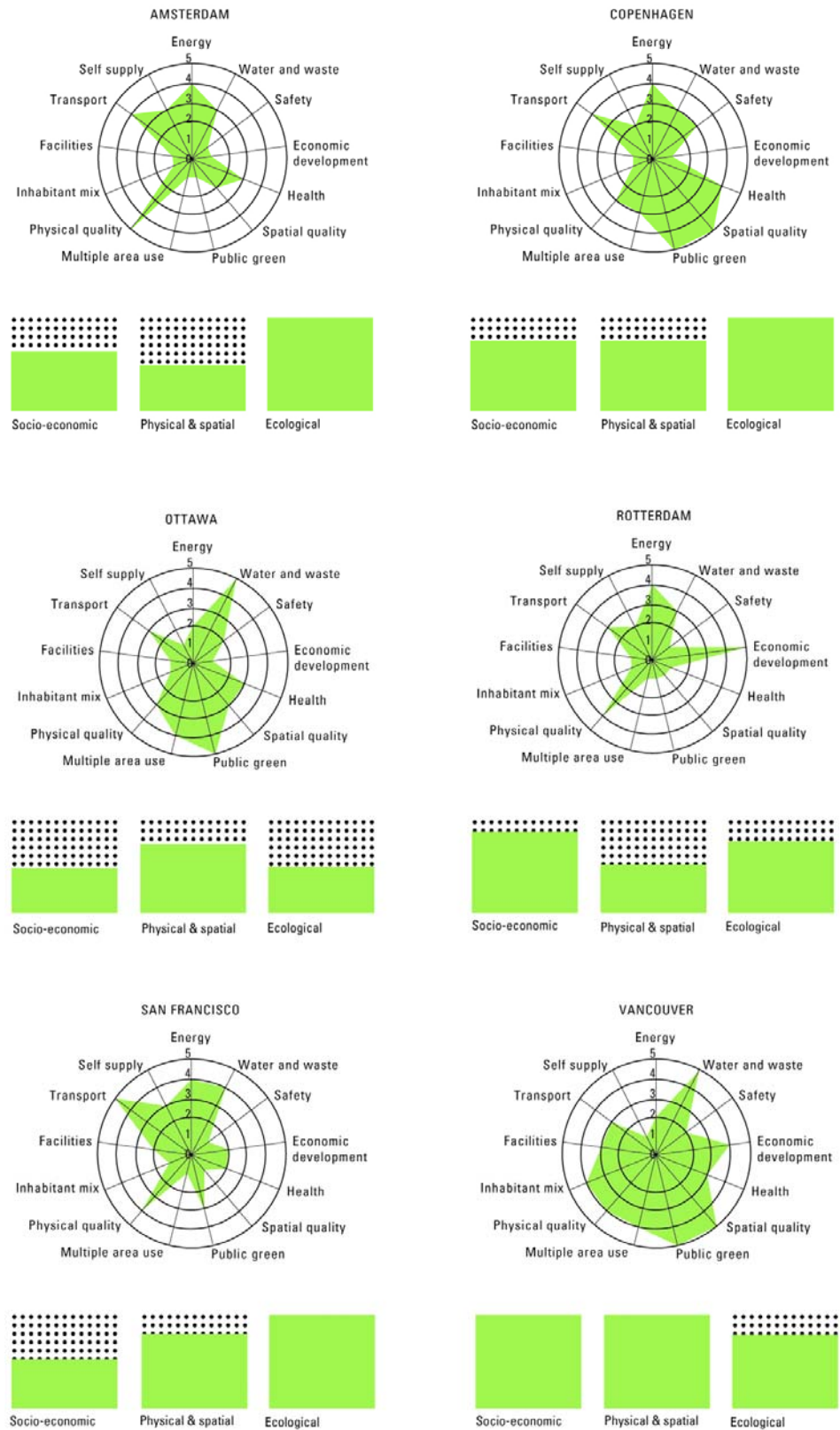
The spider webs show that the cities of Copenhagen, Ottawa and Vancouver pay much attention to their spatial planning as part of the overall urban sustainability approach. The cities of Amsterdam, Copenhagen and Rotterdam pay much attention to energy related issues. The attention for water and waste is high in all cities and transport has a fair amount of attention in all cities too. Economic development in relation to sustainable urban development is a central issue in the cities of Rotterdam and Vancouver. Attention to issues like amenities and inhabitant mixing – as part of the urban development strategy – is only found in Vancouver. Safety is another issue that is seldom integrated in the sustainability policies.

The attention for specific issues that are related to sustainability does not directly guarantee that the city scores better on the related quality aspects. However in our study we found a clear and significant correlation, although the level of actual success does differ. A general conclusion, based on the total overview, could be that the more integral sustainability approaches (like in Copenhagen and Vancouver) yield the best overall results, as also might be expected. Approaches that are more fragmented have more problems to remain upright on the longer term and to yield substantial results.

This might partly be explained by the fact that the integral approaches are generally better integrated in the total policy processes and in the thinking of all persons and parties involved. For example, in the cities of Ottawa and Vancouver, a sustainability checklist is used for each municipal decision that is taken on the development of the city.

Another general conclusion – also based on the socio-economic analysis in Chapter 3 – is that the most successful approaches for sustainable urban development do have the social and physical health of the citizens as their primary goal, obviously flanked by other targets.

4.2 City profile used to strengthen the approach

Another interesting observation is that each of the cities has chosen a strong individual characteristic as "signboard" for the promotion of their sustainability action plans. The City of Amsterdam uses its long history in combination with its topical position as IT-hub. The City of Copenhagen also starts from the need to protect the old city on one hand and the will to innovate on the other. For the City of Ottawa its green character is the signboard and for the City of Rotterdam its delta position and harbour industrial complex. For the City of San Francisco it is the bay area and the City of Vancouver specifically builds on its economic dynamic character. Rotterdam has a long history of living with water which has led to the city region becoming one of the worlds leading knowledge centres on the issues about sustainable water management, dredging, sand suppletion and coastal protection.

We can not conclude that basing sustainable urban (re)development policies on existing recognisable city profile elements is a prerequisite for success, but it is remarkable that all the considered exemplary cities use this approach. We therefore at least recommend considering the possibility.

4.3 Compactness and multiple area use

Working on city compactness and multiple area use (sometimes referred to as "eco-density") is an issue in most of the cities that have been analysed. It is motivated by the fact that high densities use space more efficiently and avoid urban sprawl. Density also supports all kind of services within the city; public transport, shops and amenities need a certain "mass" to be cost efficient. High densities generally reduce fossil fuel emissions, as people live closer to the places where they work, shop and spend spare time. From a social point of view higher densities lead to more choices for people to fulfil their needs. It also adds diversity, safety, vitality, and opportunities for creative interaction. Finally, it helps to keep the local economy vibrant and healthy and enables public health to benefit from more walking and biking.

However, high density generally is only widely accepted when it really leads to better amenities and meets certain minimum standards of function mixing and liveliness. For example, the City of Rotterdam is facing a migration of well educated citizens to neighbouring (suburban) municipalities. Available sites in the city centre and waterfront area are now appointed for the development of urban lifestyle apartments and should provide for a new attractive

and lively city environment. Other areas are appointed for the development of "suburban" like neighbourhoods for young families. These developments will help to limit the suburbanization to the surrounding municipalities.

We conclude that compactness and density are important, although not sufficient, characteristics of a sustainable city. It is crucial how issues like affordability, liveability and economic vibrancy but also the relation rental non-rental are dealt with. City administration and planners need to seek a balance between (long-term) profits of intensified density and the interest of the existing local communities. Public participation and individual entrepreneurship can play a role in finding the right balance.

4.4 Public green

One of the lessons that the cities in our selection seem to have learned is that the volume of public green and quality of parks should not suffer from growth of the city, but, on the contrary, have to grow along with the city's growth. The quality of existing parks can be improved by optimizing the usability of the park and redesigning it to serve the needs of the surrounding neighbourhood better.
Expanding green areas generally is considered to be too costly, also because of scarce space and pressure from residential and commercial developments. Using land already owned by the city like under freeways, school yards or allotment gardens are examples of potential interesting new green areas. Examples show that the city's budget is not the only option to finance public green. For instance a Park Improvement District is a public-private partnership in which businesses and/or residents in a defined area pay an additional tax in order to fund improvements and maintenance for the park. Another option is to let developers pay for new green space.

In relation to the citizen participation (see Paragraph 4.5) we would like to conclude that parks should not be planned and maintained top down; citizens can play an active role.

4.5 Citizen participation

A city is composed of people as well as the places where they live; it is as much a social environment as a physical environment. In all six cities we see examples (most of the time still small-scale at the moment) where citizen participation experiments are done on the creation of sustainable cities and communities. These experiments show that citizen participation is of great importance for the supporting and maintaining of sustainability initiatives.

In the City of Amsterdam the GWL terrain is a good example of citizen participation. This participation resulted in an oasic green living environment with a strong social cohesion in a highly dense environment. At the start of the project, ten years ago, high sustainable ambitions were set. The most extreme was that cars were forbidden. This created space for social cohesion and a lot of green spaces in the neighbourhood, for example in the form of vegetable gardens and public green. This part of Amsterdam is nowadays a very popular high-density neighbourhood to live in.

The Placemaking Project in Vancouver Glenville Island is an example of how a great district can emerge, even on an unlikely location, since local people identified the area's unique potential and worked hard to create vital public spaces. The current island's status as one of Vancouver's favourite spots isn't due to some ingenious stroke of master planning, but to the steady, patient progress of local people, organizations and businesses.

Citizen participation also played a central role in an initiative of the City of Rotterdam to keep high income families in the city and to simultaneously stop the increasing decay of her districts. The city launched the so-called Klushuizen project, in which the local government granted a totally run-down housing block to current and future tenant-owners for free, with the condition that they would invest a substantial amount of money (the minimum was defined) in their houses to make these liveable. In one of these projects the tenants even transformed the housing block into an architectonic highlight that lifted-up the image of the whole district, created extra open space and led to relatively low costs of living for the owners.

From this we draw the conclusion that sustainable urban (re)development should be organized around people, rather than around cars or around GHG protocols, etc. The citizens are a "hidden" force in society. A force that is not mobilized easily, but which can play a crucial role in the realisation of most physical policy elements as well in social cohesion, safety, etc.

4.6 The cultural and demographic aspect

The six cities considered – even though all large Western cities – show substantial differences in their cultural and demographic profiles. E.g. in Copenhagen most citizens are mostly white and from western cultures, while in Amsterdam and Rotterdam almost half of the citizens have a non-western cultural background. In the City of Vancouver population growth is driven primarily by immigration. Immigrants account for 40% of the region's population. Ottawa is the most educated city in Canada, with a low average age; about 50% of the citizens are under the age of 35.

The cultural background of the citizens to a substantial extent defines how they react on urban development measures. For example, where generally a high percentage of people prefer a family home of their own, other people (like the immigrants from Hong Kong in Vancouver) have no problem at all with living in skyscraper buildings and a highly compact city centre. All cities are more or less struggling to find the right balance and the right answer to the cultural differences.

On top of the cultural differences most of the cities also will have to deal, at increasing speed, with the ageing of their citizen populations, which will lead to new requirements and new conditions.

We consider it important that the results of the current urban (re)development policies will hold for a very long period of time. Therefore it is crucial that these policies not just start from the inhabitant mix of this moment but also think about both the likely and potential developments, like ageing of the population and immigration.

4.7   Ecological aspects

The effectiveness of policy measures in the area of energy and ecology is strongly interrelated with the measures in the other policy fields. The approaches in Vancouver and Copenhagen, and to a certain extend also in Rotterdam, clearly show that investments in energy efficiency and cleaner technology might well go hand in hand with socio-economic growth and spatial quality.
Central leadership, enthusiasm and directorship are important success factors for the realisation of energy and environmental policies. The approaches in Amsterdam, Copenhagen and Vancouver show obvious examples of this effect. Creating room for initiatives of private parties and citizens can lead to very appealing results too.
However, even though good results can be realised by approaches that create conditions and stimulate people, this does not yield sufficient results in all areas and for all groups of people. This is one of the reasons that several of the exemplary cities tend towards more mandatory approaches, to deal with the more difficult dossiers and those who stay behind.
Particularly in this field co-operation at regional, federal or even international level is required. This is a complex matter for individual municipalities, that requires a lot of effort, but also potentially yields the most significant results.

4.8   Policy implications

The conclusions on the different aspects lead to a series of recommendations on both the strategic municipal approach for sustainable urban development and the more operational actions. The interrelation between the different recommendations is visualised in Figure 18.

The upper part in this picture represents the strategic approach.
This approach has to be integral and organized around the needs of the citizens in the first place. However, in many cases municipalities have to look further, as they house companies and industries that serve a much wider area. An extreme example is the harbour industrial complex of the City of Rotterdam, which serves North-West Europe. The sustainable development of areas like these requires a close co-operation with both the organisations involved and the federal government.

From these two angles (the citizens and the wider importance of the city) an integral vision for the future of the city can be drawn-up, which takes into account the long-term federal policy intentions as well local cultural and demographic characteristics and expected developments. The resulting strategy for the urban sustainable development can then be laid down in an integral strategy document.

The strategy will have to be translated into a concrete set of actions. A tool that might help for this purpose is a standard sustainability checklist for all policy decisions. Other success factors that can be mentioned based on the analyses in this report are leadership and enthusiasm, long-term consistency and citizen participation.
Packages of building blocks will have to be composed for the realisation of the policy intentions. A set of generally usable buildings blocks is indicated in Figure 18 and elaborated on below.

Figure 18   Building blocks and points of interest for a successful approach
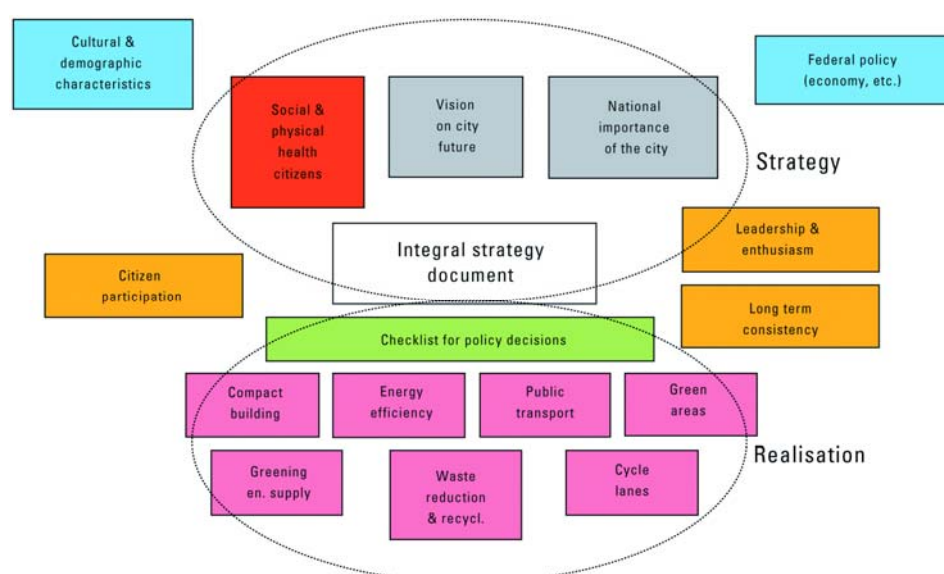
In the realisation process the city holds a number of "tuning knobs" that can be operated to obtain results. The art is to find the right mix and the right "volumes" for the different knobs. In the tuning process the following scheme, based on the analyses in this report, might be of help.

Table 2   Provisional relation scheme for the turning knobs and their effect

		HEALTH	SAFETY	ECONOMIC DEVELOPMENT	AIR QUALITY	LIVING ENVIRONMENT	STORM WATER	INDEPENDENCE
URBAN PLANNING	compact building / density		■	■	■	■		
	multiple area use / mixing		■	■				
	amenities		■	■		■		
	green areas / green roofs	■	■	■	■		■	
	public transport		■	■	■			
	cycle lanes / parking	■	■	■	■	■		
	storm water reservoirs						■	
ENVIRON. POLICY	energy efficiency	■			■			■
	greening of energy sources							■
	waste reduction / recycling			■		■		
	water management			■				

In this scheme the different tuning knobs are presented on the lines of the table and the desired results in the columns. The relations between the knobs and their effects in the field of sustainability is presented by different colour intensities. The pink squares indicate a potentially negative effect.

4.9 Recommendations for a successful policy approach

Taking all the experiences and results into account we can draw-up a table with recommendations for the process of sustainable urban (re)development policy planning. The table includes general recommendations based on the analysis of the six exemplary cities, literature research on sustainable urban development in other parts of the world and on the expert opinion of the researchers.

The first part of this table gives a series of starting points or guiding principles for the policy approach of sustainable urban (re)development in general. The second part offers a series of more concrete and more physical elements that might be taken into account in any (re)development project.

Sustainable urban (re)development
Guiding principles for the general approach   - Take social and physical health of the citizens and the desired future of the city as central aims.   - This will lead to a practical and balanced synergy of socio-economic, spatial and ecological quality aspects.   - Draw-up a sustainability checklist and assess and adjust all future policy decisions, based on this list.   - Frequently evaluate and innovate the policy targets, but take care of long-term consistency and gradual transitions (= more difficult than it seems!).   - Stimulate private initiative and citizen participation.   - At the same time set minimum mandatory standards, to make sure that laggards have to start moving too.   - Stimulate long-term involvement of project developers, to prevent ad-hoc profit seeking developments that thwart the planning strategy.   - Actively negotiate and co-operate with other regional, federal and international governments on issues that are outside the individual jurisdiction. Try to get an exceptional status.   - Select a clear "signboard" for the approach and preferably link this to existing strong elements city profile.
Concrete elements to be considered   - Compact building, particularly filled-in with multiple area use and function mixing.   - Energy efficiency, standards for new developments, restructuring projects and new concessions and exemplary role.   - Greening of energy supply, agreements on the use of renewable energy sources for the production of electricity and heat.   - Waste reduction and recycling, agreements and standards on the reduction of waste flows and on recycling.   - Public transport, improvement and extension of public transport systems at local and regional level.   - Cycling, offering attractive and safe cycle lanes in and towards the city centre.   - Spreading of green areas, making sure that green areas are available at short distance (different concepts are possible and effective).   - Exemplary role, the municipality gives a good example, but also uses this to stimulate others and make agreements.

The recommended guiding principles and concrete elements can thus be used to improve the sustainable urban development in any city. However, at all times the guidelines will have to be applied wisely, since obviously they do not provide ultimate truths.

In this respect we would like to emphasize once more that the analyses of the six cities in this report was purely intended to obtain a better understanding for the effectiveness of sustainable urban development strategies in general and not to judge, rank or benchmark these cities in any way.

Nevertheless, we are convinced that, with some extra elaboration, the findings of this research project can be developed into a serious measuring staff for the effectiveness of actual sustainable urban development policies in different cities. An important step in this direction has been set in this study.

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Annex A Definitions

"Development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (Brundtland Commission, 1987).

"A form of societal change that, in addition to traditional development objectives, has the objective or constraint of ecological sustainability". That is, "ecological sustainability is, of course, not independent of the other (traditional) objectives of development. Trade-offs may sometimes have to be made between the extent to and rate at which ecological sustainability is achieved vis-à-vis other objectives. In other cases, however, ecological sustainability and traditional developmental objectives (such as satisfaction of basic needs) could be mutually reinforcing" (Lélé, 1991).

Health, according to the World Health Organisation (WHO) definition is "a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity" (WHO, 1992).

"Sustainable urban development seeks to create cities and towns that improve the long-term health of the planet's human and ecological systems" (Wheeler, 1996).

Definition of "ecological footprints"
Its premise is that each of us has real areas of the earth's surface dedicated to our consumption of food and wood products (footprints of the same name); to our use of land surface for buildings, roads, garbage dumps, etc. (degraded land footprint); and to forests necessary to absorb CO_2 produced by our burning of fossil fuels (energy footprint). The sum of these footprints can be calculated and constitutes our ecological footprint (Palmer, 1999).

"Improving the quality of life in a city, including ecological, cultural, political, institutional, social and economic components without leaving a burden on the future generations" (URBAN21 Conference Berlin, 2000).

Definition of "urban metabolism"
This model asses sustainability, but rather than calculating the amount of land required to sustain the resource consumption and waste discharge of any given population, it measures the flow of resources into and waste outputs from settlements (DoI, 2002).

Definition of "industrial ecology"
Industrial ecology is an emerging field of study that aims to improve the sustainability of industrial metabolism by applying an ecological metaphor to the design of industrial systems. Industrial ecologists attempt to address the need for an urgent yet practical revision of conventional industrial system design (Verstegen, 2003).

"Het op zodanige wijze ontwerpen; bouwen en inrichten, gebruiken en beheren van de stedelijke omgeving dat de schade voor de gezondheid en het milieu in alle stadia van het bestaansproces, van ontwerp tot en met sloop, zoveel mogelijk wordt beperkt voor nu en in de toekomst" (Nationaal Pakket Duurzame Stedebouw).

"(…) duurzame, steden zijn flexibel. De stadsplattegrond gaat lang mee en is door de decennia en eeuwen heen elke keer opnieuw in staat om ruimte te bieden aan nieuwe functies en te voldoen aan nieuwe eisen" (Dubbeling, 2009).

As economic development can only be sustainable when it is accompanied by measures designed to reduce poverty, social exclusion and environmental problems, the integrated approach not only encourages growth and jobs throughout Europe, but also pursues social and environmental objectives (Green Paper on Territorial Cohesion – Turning diversity into strength, COM (2008)).

"A city - or, better, even, a metropolitan area - that does not rob the earth of fixed, non-renewable resources, or, if it does, it does so at only a minimal and a decreasing rate" (Hall, 2005).

"The real question is whether the notion of sustainable urbanism is a mythical beast."
"(…) we have to start with what has become almost conventional, even commonplace, nowadays. This is the much-quoted, perhaps now over- quoted, statement from The Brundtland Report nearly 20 years ago. We all know it almost by heart. "The real question is, in any context - not least the urban context - how to make it operational" (Hall, 2005).

Annex B Total list indicators/parameters

Process of formulation indicators and parameters

From two basic principles is started with the drawn-up of the indicators:
1. Key concepts on sustainable urban (re)development: ecologically sustainable, socially liveable and economically healthy.
2. Analysing used indicators in different ranking systems for sustainable cities. Especially we looked at indicators where high ranking cities score very high on specific indicators.

The first basic principle is used to clustering the indicators on what is the thread and what are the distinguished groups?
The second principle provides the following information:
– The criteria of some ranking systems are unclear (like EuropeanCitiesMonitor of Cushman& Wakefielden and The Economist's World's Most Livable Cities).
– At others ranking systems, the available information differs.
– So totally ten ranking systems left with more than 250 indicators (a lot of overlaps).

Then we clustered all the different indicators and parameters and make some head groups, Figure 19.

Figure 19   Making head groups of the indicators and parameter

Overview indicators and parameters physical and spatial quality

Indicators	Parameters
Density	Inhabitants per km^2 Dwellings per km^2
Mixed use	*Jobs/housing ratio (neighbourhood/district)* *Dispersion of services (schools, grocery stores, restaurants).*
Public green (parks)	Area of green per inhabitant *Accessibility of green, % of inhabitants living within 500 m of public green*
Urban form	Typology of building blocks (descriptive indicator) Grid layout (descriptive indicator)
Energy efficient buildings	Number of energy efficient buildings per 100.000 inhabitants

Overview indicators and parameters social and economic quality

Indicators	Parameters
Economic quality (prosperity)	*City product per capita* Employment (descriptive indicator) *Distribution of income/average income* *Economic stability* Affordability (descriptive indicator) Demography (descriptive indicator)
Social quality (well-being)	Safety (descriptive indicator) Demography (descriptive indicator) Citizen participation (descriptive indicator) Identity (descriptive indicator) *Social equity*
Level of amenities	*Health* *Education* *Entertainment*

Total overview indicators and parameters ecological quality & flows

Indicators	Parameters	Relation with the sustainable city
Total GHG emissions	Total GHG emissions of at least two years	GHG emissions gives an indication of the absolute emissions of a city. This can be determined by certain core industrial activities, the climate or typical consumer behaviour (VS versus Europe). Useful to compare with population growth or economic shifts.
Residential GHG emissions	Residential GHG emissions of at least two years	Residential GHG emissions indicate whether the energy demand of the residential sector is provided by relative clean energy, or that houses are relatively energy efficient. Trends in this figure are useful to compare to the trend in population growth or total GHG emissions.

| Indicators	Parameters	Relation with the sustainable city
GHG emissions per capita	- Total GHG emissions of at least two years - Number of Inhabitants	This figure makes cities more comparable. And also gives an indication of the energy intensity of a city, which can be determined by numerous factors as described for the above indicators.
Residential GHG emissions per capita		Since household size is stable a change in this figure indicates that the energy supply becomes cleaner, energy efficient measures are taken or consumer behaviour changes.
Residential energy use share	- Share of electricity use - Share of gas use - Share of renewable/heat use	The shares between different residential energy sources provide an overall view on the pollution intensity of household energy use.
Solid waste production residential sector per capita	- Total solid waste production residential sector of at least two years - Number of households	Solid waste production is a challenge for a city's self sufficiency. Although waste can be recycled or used as energy source, the remainder goes to growing landfills. Less waste is always better to this respect. Landfills emit GHG.
Recycling percentage of residential waste	Share of residential waste recycled	Indicates the share between recycled waste and waste with no solution (although this figure does not differentiate between landfill waste and energy source waste).
Water consumption per capita	- Total residential water use of at least two years - Number of inhabitants	Water consumption is important for a city's future self sufficiency. Regional water levels and periodic draughts can have a profound impact on the water supply.
Travel mode to work	Share between travel modes to work	Travel mode share is an important indication for the mobility flows of a city. All modes have a distinctive pollution factor related to GHG emissions and air pollutants.
Air quality trends	- Concentration level of PM_{10} for several years - Concentration level of NO_2 for several years - Concentration level of O_3 for several years - Concentration level of $PM_{2.5}$ for several years	Air quality has a profound impact on human health and the natural environment. It is directly linked to mobility and local electricity production. It is also determined by factors which cannot be influenced, like sea salt and meteorological conditions. Compact cities are likely to experience air quality problems, since pollutants need to disperse in order to diminish their health and environmental impact. The receptor density is also a determinant of air quality problems.

Annex C   Ranking lists and systems

Figure 20   Overview of the twelve ranking systems for "most sustainable cities"

	Name	From	Year	Scope
World	Quality of living global city rankings	Mercer	2009	Worldwide, Not specific on "sustainability"
	The economist world's most livable cities	The Economist	2009	Worldwide, uses Mercer data
VS	Sustainlane	Sustainlane	2008	USA, 50 biggest cities based on population numbers
	Smarter cities	Natural resources defence council's (NRDC)	2008	USA city population > 250.000
Canada	Sustainable cities report	Corporate knights	2009	17 Canadian cities
	Green Apple Canada SMART transportation ranking report	The Appleton charitable foundation	2008	Canadian cities on sustainable transport
Europe	European green city index	Siemens/economist intelligence unit	2009	30 "leading" European cities Focussed on green and energy
	Smart cities – ranking of European medium-sized cities	TU Wien, University of Ljubljana & OTB Delft	2007	Europe, 70 middle-sized cities (50.000-100.000 inhabitants)
	European cities monitor	Cushman & Wakefield	2009	Europe's 50 biggest business cities. Judged by entrepreneurs, economical view (but also quality of live)
	European green capital award	European Committee	2009	Based on own numbers from the European cities. (Policy of) cities who wants to prove the living environment as global environment
UK	Sustainable cities index	Forum of the future	2009	UK, 20 biggest cities
NL	Lokale duurzaamheidsmeter	COS Nederland	2009	NL local governments on people, planet, profit

These ranking systems are aimed at the broadest sense of "sustainability" but also the approximation to more "green" and "economic"

Figure 21   Impression of ranking systems
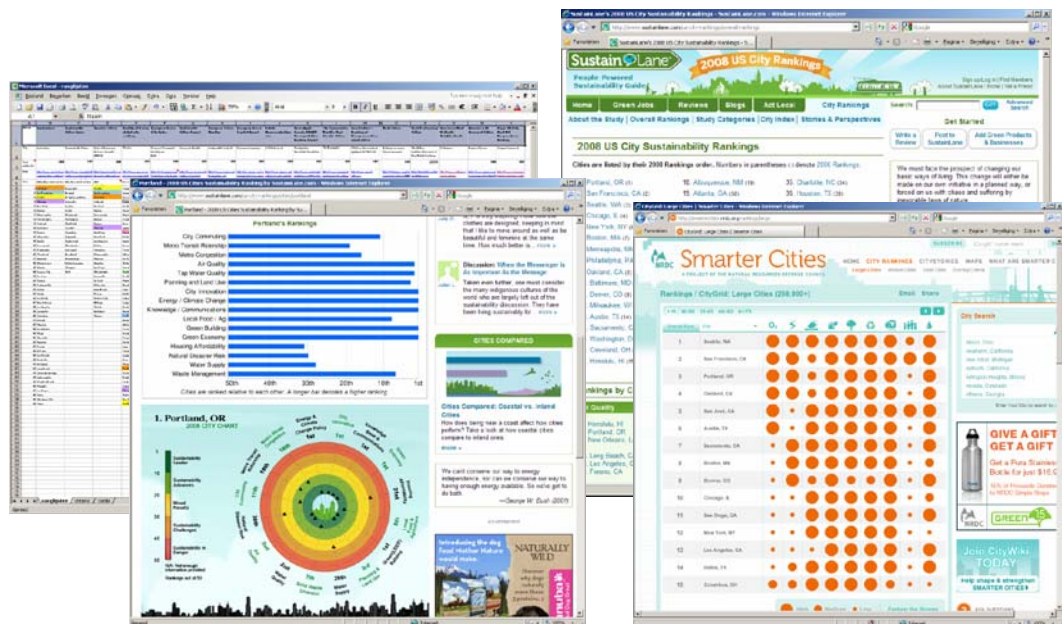
Proceeding these rankings list of sustainable cities we made the next longlist of sustainable cities.

Table 3   Longlist of sustainable cities

VS	Europe
Portland (broad sustainability approach)	Copenhagen (green/energy)
Seattle (broad sustainability approach)	Stockholm (green/energy)
San Francisco (broad sustainability approach)	Oslo (green/energy)
Chicago (broad sustainability approach)	Hamburg (green/energy)
Boston (green)	Munster (green/energy)
	Newcastle (broad sustainability approach)
Canada	Bristol (broad sustainability approach)
Vancouver (quality of life)	Brighton and Hove (broad sustainability appr.)
Edmonton (broad sustainability approach)	Vienna (quality of life)
Toronto (broad sustainability approach)	Zurich (quality of life)
Ottawa (broad sustainability approach)	Geneva (quality of life)
	Luxembourg (broad sustainability approach)
	Aarhus (broad sustainability approach)
	London
	Paris
	Frankfurt
	Barcelona

Annex D City profiles

The city profiles are presented in a separate annex report. This annex report offers an overview of the policy goals and approaches of the exemplary cities considered in this report. The cities are presented in alphabetic order. Per city successively the goals are given, the policies and main projects, the most characteristic data and graphical materials.