BlueSCities

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Abstract	The main purpose of this report is to combine the results from the case studies described in D3.2 and the results of the interviews from the European Green Cities: Bristol, Copenhagen, Hamburg and Oslo. It was decided that the best form of an interview is simply the application of the City Blueprint® Framework and The Trends and Pressures Framework described in Task 2.2 and The City Amberprint Framework™ developed in Task 3.1 to the cities. These findings are compared with the results from the case studies: Athens, Genoa, Helsinki and Istanbul, where the previously developed methodologies were also applied during Task 3.2 and reported on in Deliverable 3.2. Additionally, drawing from the results of Tasks 2.1 and Task 2.3 the best practices on urban water and waste treatment were researched and are presented in this document. This will facilitate the process of sharing best practices and learning from one another, which will be used later to support WP4

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Executive Summary

The main purpose of this report is to combine the results from the case studies described in D3.2 and the results of the interviews from the European Green Cities (smart cities) such as Bristol, Copenhagen, Hamburg and Oslo. These cities have an excellent track record on sustainable water and waste practices and strategies that were developed and employed to deal with these problems. It was decided that the best form of an interview is simply the application of the City Blueprint® Framework (CBF) and The Trends and Pressures Framework (TPF) described in Task 2.2 and The City Amberprint Framework™ (CAF) developed in Task 3.1 to the smart cities. These findings are compared with the results from the case studies: Athens, Genoa, Helsinki and Istanbul, where the previously developed methodologies were also applied during Task 3.2 and reported on in Deliverable 3.2. Additionally, drawing from the results of Tasks 2.1 and Task 2.3 the best practices on urban water and waste treatment were researched and are presented in this document. Summary of these best practices can be found in Table 1.1 and the full description in Chapter 4. This will facilitate the process of sharing best practices and learning from one another, which will be used later to support WP4.

Table 1.1: Summary of best practices on urban water and waste treatment and utilisation in the four smart cities

City	Title	Summary	Report section for more detail
Bristol	Open Green Doors	Ordinary citizens open their doors to showcase energy efficiency initiatives supported by council. Successful at inspiring and sharing solutions.	4.1.1
	Biogas from wastewater	Biomethane from WWTP contributes to national gas supply grid and for a pilot bas-powered city bus (to be replicated)	4.1.2
	Refuse-derived fuel (RDF) exported	RDF derived from city waste is exported to Netherlands for district heating schemes	4.1.3
	Wetland management and other open spaces initiatives	Identification of suitable sights and development of protection/enhancement programs	4.1.4 / 4.1.5
	Sustainable urban drainage schemes (SUDS)	Permeable block surfaces used to reduce and control run-off, recharge groundwater, and reduce movement of contaminated groundwater	4.1.6
	City to sea campaigns	Public engagement campaigns that inform people about tap water quality in the city, encourage to reduce waste and switch from plastic bottles to reusable ones	4.1.7
Copenhagen	Climate resilient urban green space	Tåsinge Plads. A 'green oasis' square collects and infiltrates rainwater, also providing green leisure space for citizens.	4.2.1
	Incentives and ICT for efficient energy and water use	City offers guidance and incentives combined with remote and detailed monitoring of water and energy use to improve efficiencies.	4.2.2 / 4.2.3

Copenhagen	Sustainable city of the future	Nordhavn Project will test partnerships between government institutions, corporations, utility companies, and universities	4.2.4
	District heating and cooling schemes	Using seawater and power plant steam with compressors to provide cooling, and waste heat from refuse incineration for heating.	4.2.5 / 4.2.6
Hamburg	Sector integration	Integration of water and wastewater provides synergies in organisation, human resources, asset management, procurement, ICT, in-house consultancy services, etc.	4.3.1
	Sustainable residential development (pilot)	Jenfelder Au development incorporates water cycle concept: water saving vacuum sanitation, bioenergy from wastewater, rainfall and grey water for garden/park irrigation, etc.	4.3.1
	Resource protection initiatives	Initiatives in the city that ban purchase of certain polluting products with city council money, help companies to reduce their carbon emissions, and promote recycling of waste	4.3.2 / 4.3.4 / 4.3.5
	Emission-based port fees	A discount for environmentally friendly ships in the port was introduced.	4.3.3
	The Innovative HAMBURG WATER Cycle®	A solution to recycle rainwater. greywater and blackwater in households	4.3.6
Oslo	Integrated Waste Management System	It is considered one of the most advanced systems for source separation of household waste and waste-to-energy working together	4.4.1
	Renewable shore-based electricity for ships when docked in Oslo	Ships docked in Oslo run on renewable shore-based electricity instead of fossil fuels	4.4.2
	Social media use	Public engagement campaigns to promote drinking tap water, change garden watering habits and change water consumption in general	4.4.3
	NoDig – Trenchless House Connections to Main Water Lines (NoDigChallenge)	A cost and time saving solution that will also have a positive social and environmental effects.	4.4.4

1 Introduction

The main purpose of this report is to combine the results from the case studies described in D3.2 and the results of the interviews from the European Green Cities such as Bristol, Copenhagen, Hamburg and Oslo. These cities have an excellent track record on sustainable water and waste practices and strategies that were developed and employed to deal with these problems. It was decided that the best form of an interview is simply the application of the City Blueprint® Framework (CBF) and The Trends and Pressures Framework (TPF) described in Task 2.2 and The City Amberprint Framework™ (CAF) developed in Task 3.1 to European Green Cities. These findings are compared with the results from the case studies: Athens, Genoa, Helsinki and Istanbul, where the previously developed methodologies were also applied during Task 3.2 and reported on in Deliverable 3.2. Additionally, drawing from the results of Tasks 2.1 and Task 2.3 the best practices on urban water and waste treatment were researched and are presented in this document. Summary of these best practices can be found in Table 1.1 and the full description in Chapter 4. This will facilitate the process of sharing best practices and learning from one another, which will be used later to support WP4.

The CBF is a first attempt to perform a baseline assessment of Integrated Water Resources Management (IWRM). The City Blueprint® consists of twenty five indicators divided over seven broad categories, see Table 2.5, and shows the indicator results in a spider diagram, see Figure 2.2. The City Blueprint allows for comparison with other leading cities and, thereby can promote city-to-city learning. The overall sustainability of the water and waste aspects is expressed as Blue City Index (BCI) which is the geometric mean of all CBF indicators. The indicators are scored between 0 (there is a concern) to 10 (no concern). The quantitative indicators were "normalised" on a scale of 0 to 10, where 10 points were assigned to cases that met or exceeded certain criteria on environmental performance (Koop and Van Leeuwen 2015a).

The TPF (on which the city's IWRM has a negligible influence) creates awareness of the most stressing topics that either hamper or, on the contrary, pose opportunity windows for IWRM. The Trends and Pressures indicators are standardized to a scale of 0-4 points, and the following classes have been used: 0 – 0.5 points (no concern), 0.5 – 1.5 (little concern), 1.5 – 2.5 (medium concern), 2.5 – 3.5 (concern), and 3.5 – 4 (great concern). There are twelve indicators divided into three categories: social, environmental and financial pressures, see Table 2.1 and the Trends and Pressures Index (TPI) is the arithmetic mean of the all TPF indicators (Koop and Van Leeuwen 2015b).

The CAF is a complement to the CBF and TPF. The main goal of the City Amberprint is a baseline assessment of the sustainability of Energy, Transport and ICT in cities. The city Amberprint consists of twenty two indicators: seven indicators to asses Energy aspects, seven to asses Transport aspects and eight to asses ICT aspects in a city, see Table 2.6. Similarly to the City Blueprint, the indicator results are presented in a spider diagram, see Figure 2.6. To comply with City Blueprint, the indicators that have a value between 0 (there is a concern) to 10 (no concern) are proposed. The overall sustainability of the three aspects is expressed as Amber City Index (ACI). The ACI is the geometric mean of the twenty two indicators.

2 Case study cities: Athens, Genoa, Helsinki, Istanbul

The four cities selected (Figure 2.1) as the case studies (described in Deliverable 3.2) represent a good range in terms of geographical spread, water resources, climate, population, average income and level of development (Bluescities.eu, 2016).

Figure 2.1: Location of the four case study cities: Athens, Genova, Helsinki and Istanbul

Athens, Greece

Athens is the capital and the largest city of Greece. One of the greatest issues of the metropolitan area of Athens is waste management with 35 uncontrolled waste disposal sites. Additionally, the air pollution and the lack of air circulation in Athens, due to its geographic characteristics, enhance the urban heat island effect, which increases during summer. (Bluescities.eu, 2016). Athens' climate is characterised by mild wet winters and dry summers, with an overall low annual rainfall (long-term annual average of the past 100 years = 400 mm) (Mamasis and Koutsoyiannis, 2007). Nowadays, Athens's water system has evolved, reaching the current complex shape, that consists of 350 km of main aqueducts, 4 dams, 100 groundwater boreholes spread in 4 groundwater bodies, 15 pumping stations, 4 treatment plants and 3 wastewater treatment plants (Mamasis and Koutsoyiannis, 2007).

Population: 665 000 (2014)

Households: 111 987 (2011)

Coordinates: 37° 58′ N 23° 43′ E

GDP/capita: US$ 23 600 (2016)

Area: 38.96 km^2 (2016)

Currency: Euro

Genova, Italy

Genoa is the sixth largest city in Italy. Genoa has been nicknamed la Superba ("the Proud one") due to its glorious past and impressive landmarks. Part of the old town of Genoa was inscribed on the World Heritage List (UNESCO) in 2006. The city stretches along the coast for about 30 kilometres from the neighbourhood of Voltri to Nervi, and for 10 kilometres from the coast to the north along the valleys Polcevera and Bisagno. The average per-capita domestic water consumption in 2012 was 175 litres/day (Bluescities.eu, 2016).

Population: 862 855 (2015)

Households: 416 807 (2014)

Coordinates: 44° 24′ 40″N 8° 55′ 58″ E

GDP/capita: US$ 29 600 (2016)

Area: 243 km^2 (2016)

Currency: Euro

Helsinki, Finland

Helsinki is the capital and largest city of Finland. The city boundaries cover a surface area of 715.48 km^2 while the metropolitan region covers 1,489.84 km^2. In 2012 Helsinki was the World Design Capital and celebrated its 200th anniversary as the capital of Finland. In 2014 Helsinki was awarded City of Design status as part of the Creative Cities Network established by UNESCO (Bluescities.eu, 2016; Visit Helsinki, 2016).

Population: 603 968 (2015)

Households: 315 141(2014)

Coordinates: 60° 10′ 15″ N 024° 56′ 15″ E

GDP/capita: US$ 35 900 (2016)

Area: 715.48 km^2 (2015)

Currency: Euro

Istanbul, Turkey

Istanbul, the largest city in Turkey, is located in the north-west Marmara Region of Turkey. It encloses the southern Bosphorus which places the city on two continents: the western portion of Istanbul is in Europe, while the eastern portion is in Asia. The city forms the largest urban agglomeration in Europe and is classified as a megacity (a city with a population of over 10 million people). Furthermore, Istanbul is one of the most rapidly growing cities in Europe.

Population: 14 025 646 (2015)

Households: 4 135 106 (2012)

Coordinates: 41° 00′ 49″ N 28° 57′ 18″ E

GDP/capita: US$ 15 300 (2016)

Area: 1 830.92 km^2 (2016)

Currency: Turkish Lira

2.2 Trends and Pressures

The trends and pressures indicators for the four case study cities are listed in Table 2.1 – 2.4.

Table 2.1: *Trends and pressures* in Athens. The TPI for Athens is 1.7.

			0 1 2 3 4
Trends and pressures	Social	1. Urbanization rate	
		2. Burden of disease	
		3. Education rate	
		4. Political instability	
	Environmental	5. Water scarcity	
		6. Flood risk	
		7. Water quality	
		8. Heat risk	
	Financial	9. Economic pressure	
		10. Unemployment rate	
		11. Poverty rate	
		12. Inflation rate	

0	No concern	1	Low concern	2	Medium concern	3	Concern	4	Great Concern

For Athens heat risk and unemployment rate are a great concern while flood risk and economic pressure are a concern while political instability is a medium concern.

Table 2.2: *Trends and pressures* in Genoa. The TPI for Genova is 1.4.

			0 1 2 3 4
Trends and pressures	Social	1. Urbanization rate	
		2. Burden of disease	
		3. Education rate	
		4. Political instability	
	Environmental	5. Water scarcity	
		6. Flood risk	
		7. Water quality	
		8. Heat risk	
	cial	9. Economic pressure	
		10. Unemployment rate	
		11. Poverty rate	
		12. Inflation rate	

0	No concern	1	Low concern	2	Medium concern	3	Concern	4	Great Concern

For Genova heat risk and unemployment rate are a concern while political instability, water scarcity, water quality and economic pressure are a medium concern.

Table 2.3: *Trends and pressures* in Helsinki. The TPI for Helsinki is 0.8.

Trends and pressures			0 1 2 3 4
Trends and pressures	Social	1. Urbanization rate	1
		2. Burden of disease	0
		3. Education rate	1
		4. Political instability	1
	Environmental	5. Water scarcity	0
		6. Flood risk	1
		7. Water quality	1
		8. Heat risk	0
	Financial	9. Economic pressure	1
		10. Unemployment rate	2
		11. Poverty rate	0
		12. Inflation rate	1

0	No concern	1	Low concern	2	Medium concern	3	Concern	4	Great Concern

The unemployment rate is the most significant concern In Helsinki (being a medium concern).

Table 2.4: *Trends and pressures* in Istanbul. The TPI for Istanbul is 2.4.

Trends and pressures			0 1 2 3 4
Trends and pressures	Social	1. Urbanization rate	2
		2. Burden of disease	1
		3. Education rate	1
		4. Political instability	3
	Environmental	5. Water scarcity	2
		6. Flood risk	4
		7. Water quality	2
		8. Heat risk	4
	Financial	9. Economic pressure	3
		10. Unemployment rate	3
		11. Poverty rate	1
		12. Inflation rate	4

0	No concern	1	Low concern	2	Medium concern	3	Concern	4	Great Concern

In Istanbul flood risk, heat risk and inflation rate are a great concern to the city and political instability, economic pressures and unemployment rate are a concern.

2.3 City Blueprint

The City Blueprint indicators and their scores for Athens, Genoa, Helsinki and Istanbul are listed in Table 2.5

Table 2.5: List of City Blueprint indicators for Athens, Genoa, Helsinki and Istanbul

Category	No.	Indicator	Athens	Genoa	Helsinki	Istanbul
I	1	Secondary WWT	9.2	9.4	9.8	3.5
	2	Tertiary WWT	8.6	8.4	9.8	3.4
	3	Groundwater quality	5.0	6.5	9.8	4.0
II	4	Solid waste collected	5.4	2.7	8.7	4.9
	5	Solid waste recycled	1.9	4.1	8.5	0.1
	6	Solid waste energy recovered	0.0	2.6	8.6	0.0
III	7	Access to drinking water	10	10	10.0	10
	8	Access to sanitation	9.5	8.9	9.9	10
	9	Drinking water quality	10	9.8	10.0	10
IV	10	Nutrient recovery	0.0	8.7	9.8	1.2
	11	Energy recovery	9.2	4.7	9.8	0.2
	12	Sewage sludge recycling	9.2	8.8	9.9	3.5
	13	WWT Energy efficiency	6.0	4.0	10.0	5.0
V	14	Average age sewer	8.0	2.0	4.0	8.0
	15	Operation cost recovery	3.6	4.3	7.9	3.6
	16	Water system leakages	5.6	4.8	6.4	5.0
	17	Stormwater separation	9.7	8.7	9.5	2.4
VI	18	Green space	0.0	3.8	9.3	1.3
	19	Climate adaptation	5.0	4.0	7.0	4.0
	20	Drinking water consumption	7.3	8.0	9.0	9.7
	21	Climate robust buildings	5.0	3.0	7.0	2.0
VII	22	Management and action plans	5.0	3.0	8.0	4.0
	23	Public participation	3.5	4.2	5.0	2.0
	24	Water efficiency measures	6.0	3.0	4.0	4.0
	25	Attractiveness	9.0	1.0	8.0	7.0
		Blue City Index (BCI)	4.9	4.9	8.2	3.4

Categories: I – Water quality, II – Solid waste treatment, III – Basic water services, IV – Wastewater treatment, V – Infrastructure, VI – Climate robustness, VII – Governance

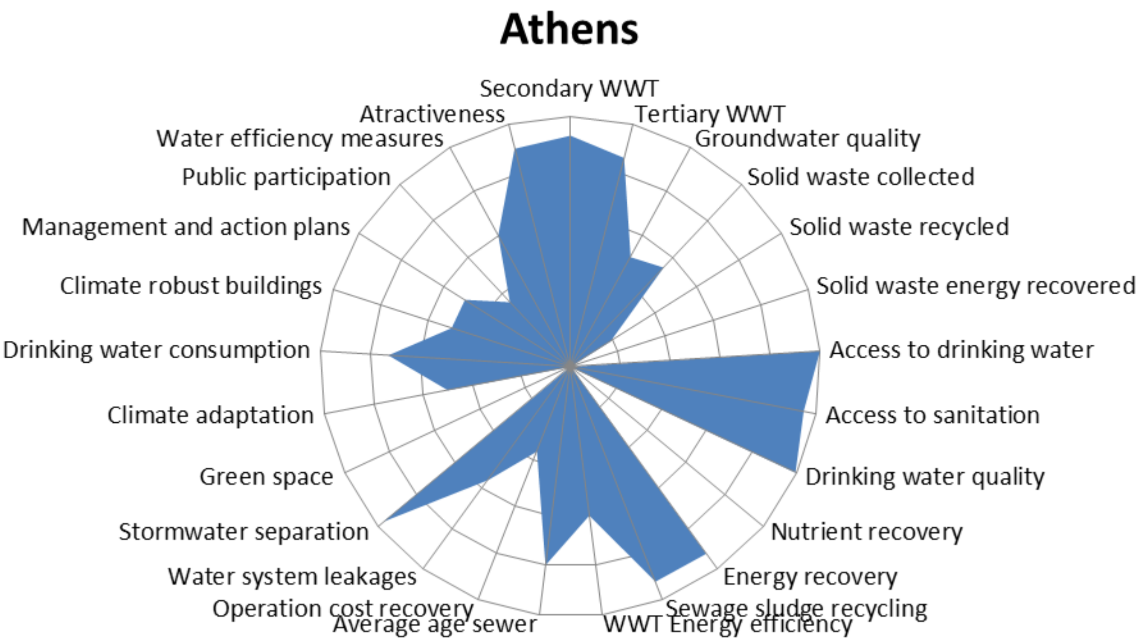

Figure 2.2: City Blueprint of Athens. A score of 0 (inner circle) means that further attention is needed and a score of 10 is an excellent score (outer circle). The Blue City Index is 4.9.

City of Athens performs very well (with a score 8 or higher) in 10 of the indicators, see Figure 2.2. However, solid waste recycled, solid waste energy recovered, nutrient recovery and green space score very low. In order to become water-wise city, Athens needs to improve these scores.

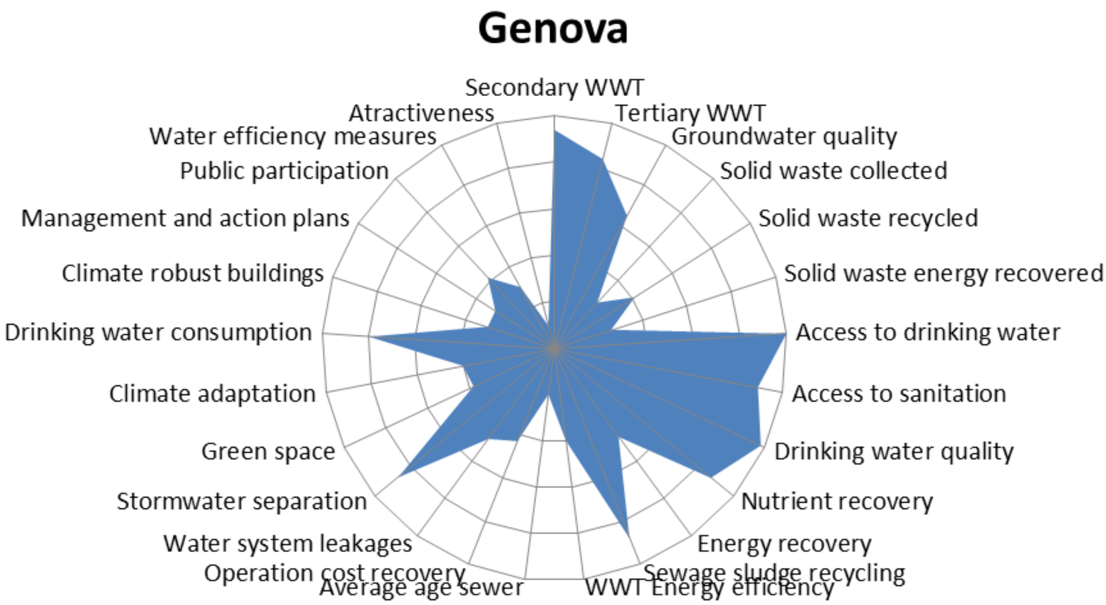

Figure 2.3: City Blueprint of Genoa. A score of 0 (inner circle) means that further attention is needed and a score of 10 is an excellent score (outer circle). The Blue City Index has a score of 4.9.

In Genova there is an opportunity to improve management of blue and green spaces in the city. Additionally, the city would benefit from solid waste treatment development.

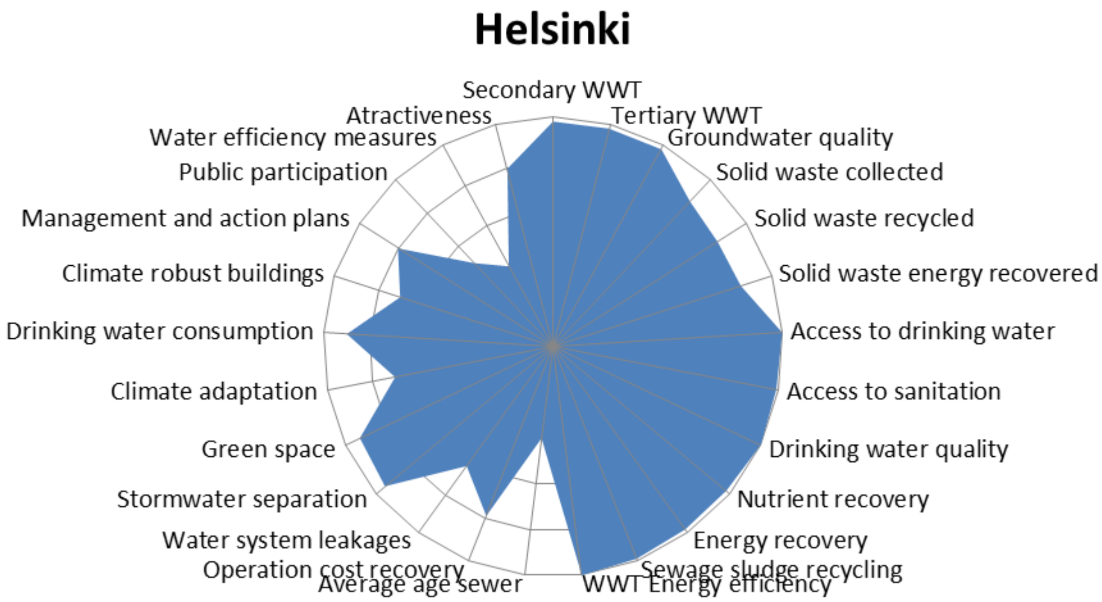

Figure 2.4: City Blueprint of Helsinki. A score of 0 (inner circle) means that further attention is needed and a score of 10 is an excellent score (outer circle). The Blue City Index has a score of 8.2.

In Helsinki most of the indicators' scores are very high. However, the infrastructure for wastewater collection is in need of replacement resulting in a score for average age sewer equal to 4. Water efficiency measures and public participation in the city also would benefit from more attention.

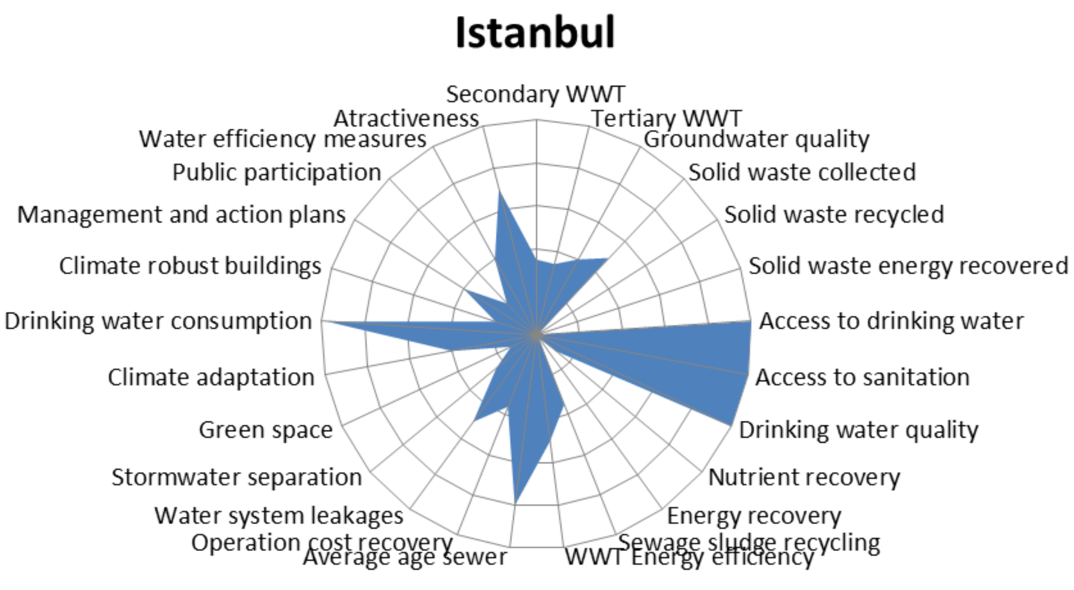

Figure 2.5: City Blueprint of Istanbul. A score of 0 (inner circle) means that further attention is needed and a score of 10 is an excellent score (outer circle). The Blue City Index has a score of 3.4.

In Istanbul solid waste management and wastewater treatment need to be improved. The city could benefit from introducing public engagement campaigns and action plans to increase water saving measures.

2.4 City Amberprint

The City Amberprint indicators and their scores for four case study cities are listed in Table 2.6.

Table 2.6: List of City Amberprint indicators for Athens, Genoa, Helsinki and Istanbul

Category	No.	Indicator	Athens	Genoa	Helsinki	Istanbul
ENERGY	1	Carbon footprint	9.8	6.6	6.75	6.4
	2	Fuel poverty	7.9	9.6	9.1	8.8
	3	Energy consumption	7.1	9.6	7.6	2.5
	4	Energy self-sufficiency	3.2	10	3.5	0.2
	5	Renewable energy ratio	1.3	0.4	0.8	3.6
	6	Energy efficiency plans	8.0	6.0	8.0	5.0
	7	Energy infrastructure investment	1.8	4.1	1.2	5.7
TRANSPORT	8	Commuting time	6.9	0,3	4.3	3.5
	9	Use of public transport	2.0	1.5	2.7	0.0
	10	Bicycle network	0.3	1.0	9.4	0.3
	11	Transportation fatalities	9.5	9.7	10.0	10.0
	12	Clean energy transport	4.0	6.0	7.0	6.0
	13	Transport-related pollutions	8.5	8.5	9.7	10.0
	14	Transport infrastructure investment	5.4	0.3	2.6	0.0
ICT	15	ICT access	5.3	4.8	7.4	5.0
	16	ICT use households	9.0	7.6	9.1	5.4
	17	ICT use water utilities	7.3	8.0	8.5	8.3
	18	ICT use energy utilities	7.5	8.5	9.0	7.5
	19	ICT use transport	3.3	7.5	8.0	7.8
	20	ICT use waste management	2.0	7.3	8.8	6.3
	21	Digital public service	5.8	2.3	8.1	7.0
	22	ICT infrastructure investment	4.1	3.5	10	7.2
		Amber City Index (ACI)	4.7	4.4	6.1	4.1

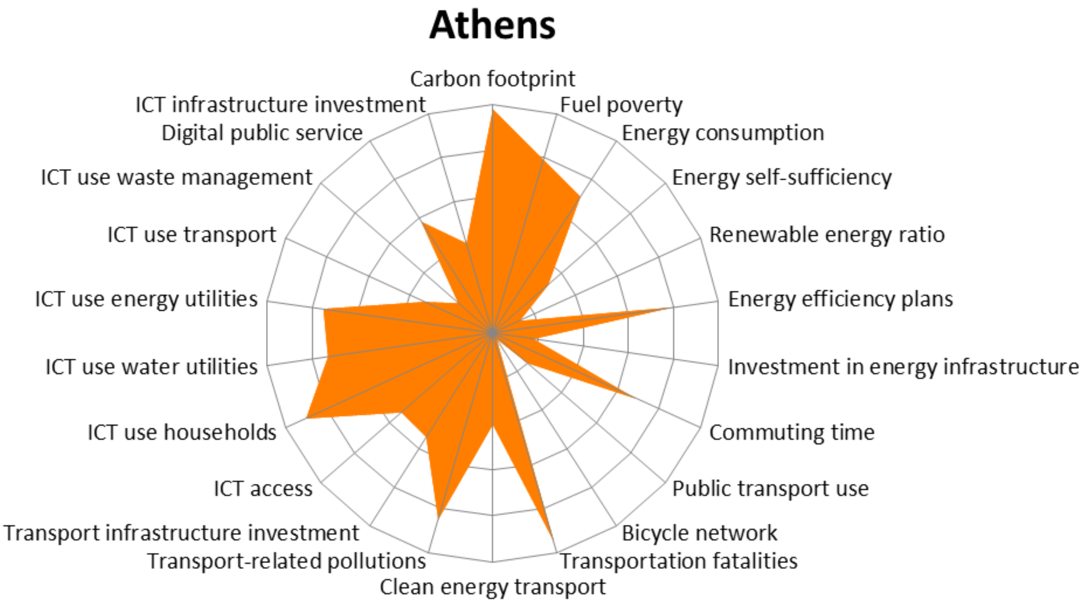

Figure 2.6: City Amberprint of Athens. A score of 0 (inner circle) means that further attention is needed and a score of 10 is an excellent score (outer circle). The Amber City Index has a score of 4.7.

In Athens the average performance in each of the three aspects is similar with a score close to 6. Investment in energy infrastructure and renewable energy ratio both have scores below 2 and are the weakest amongst energy indicators. In a case of transport indicators, the bicycle network and use of public transport need immediate attention. ICT tools are not as much in use when it comes to transport and waste management (scoring 3.3 and 2 respectively) as in water and energy utilities (with scores 7.3 and 7.5 respectively).

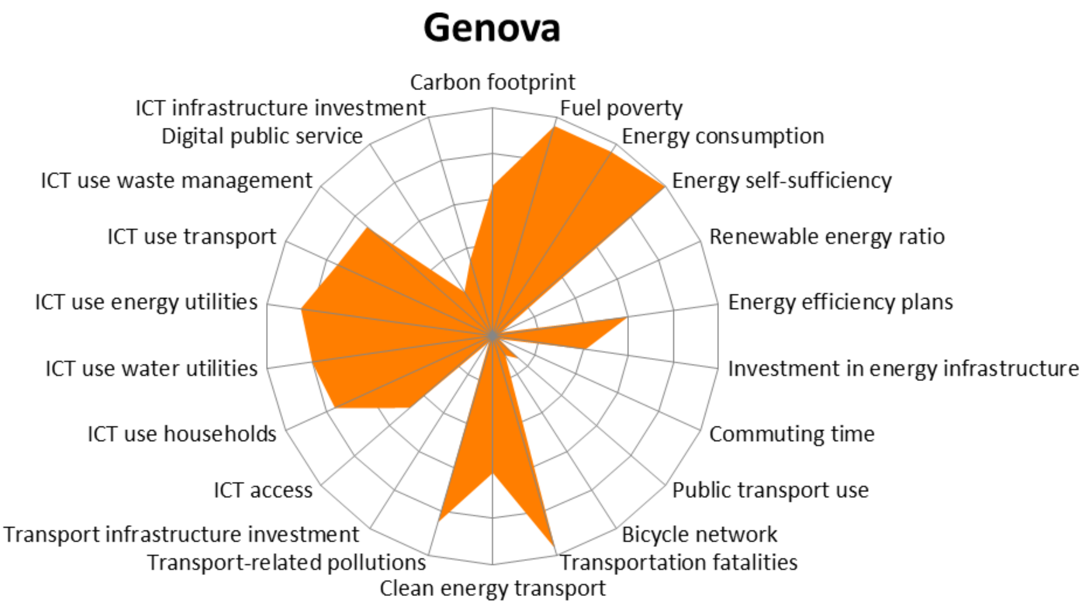

Figure 2.7: City Amberprint of Genoa. A score of 0 (inner circle) means that further attention is needed and a score of 10 is an excellent score (outer circle). The Amber City Index has a score of 4.4.

In Genova the energy aspects are the strongest in the city with an average in this category of 6. The lowest scoring indicator here is renewable energy ratio and is worth looking into. Commuting time and investment in transport infrastructure have the lowest score in case of transport indicators. They are followed closely by low scores on indicators such as use of public transport and bicycle network. ICT tools are widely used in the city. However the investment in ICT infrastructure is relatively low.

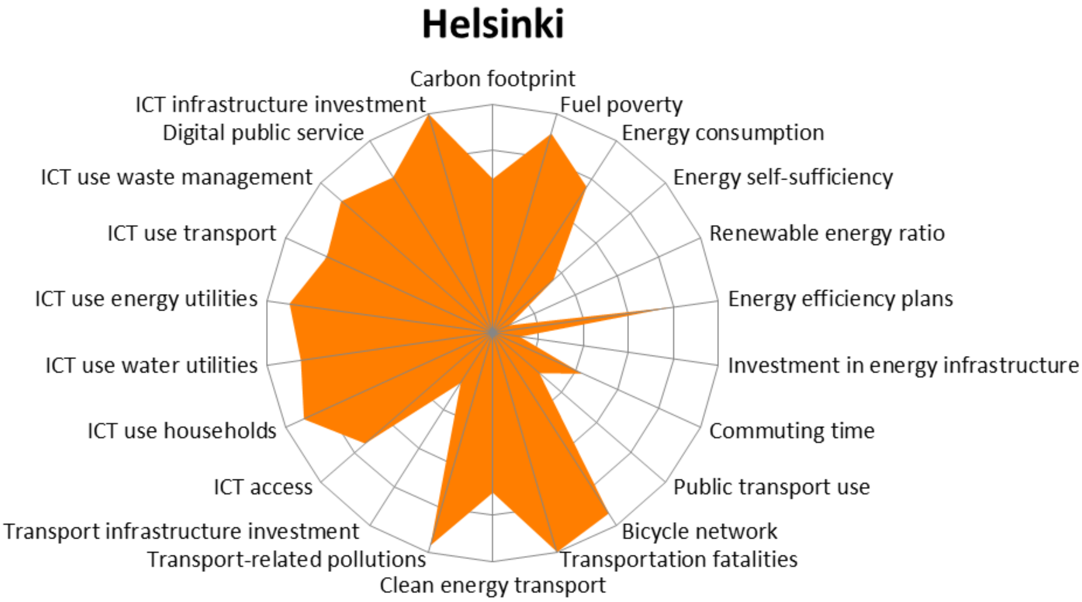

Figure 2.8: City Amberprint of Helsinki. A score of 0 (inner circle) means that further attention is needed and a score of 10 is an excellent score (outer circle). The Amber City Index has a score of 6.1.

In Helsinki ICT tools are widely used in the city. Both, energy and transport infrastructure investment have very low scores compared to ICT infrastructure investment. Renewable energy ratio has a lowest score amongst energy indicators. Public transport in not widely used in the city resulting in low score for this indicator.

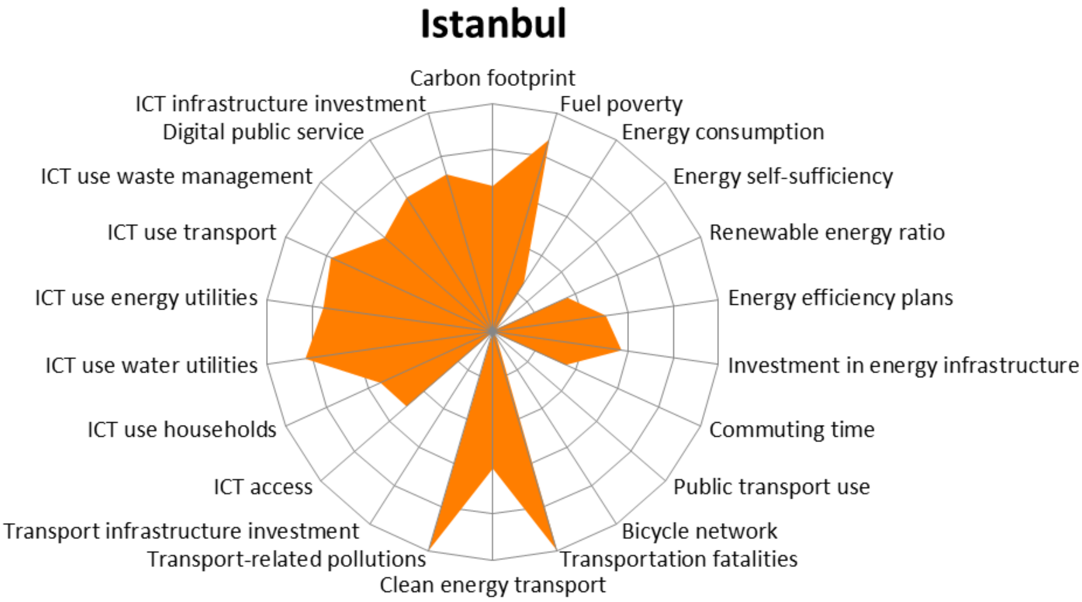

Figure 2.9: City Amberprint of Istanbul. A score of 0 (inner circle) means that further attention is needed and a score of 10 is an excellent score (outer circle). The Amber City Index has a score of 4.1.

In Istanbul ICT aspect is the strongest among the three. The lowest scores for transport indicators are for infrastructure investment, use of public transport and bicycle network. Energy consumption in the city is relatively high resulting in a low score for the indicator.

3 European Green Cities: Bristol, Copenhagen, Hamburg, Oslo

Bristol, Copenhagen, Hamburg and Oslo (Figure 3.1) have an excellent track record on sustainable water and waste practices and strategies that were developed and employed to implement these practices.

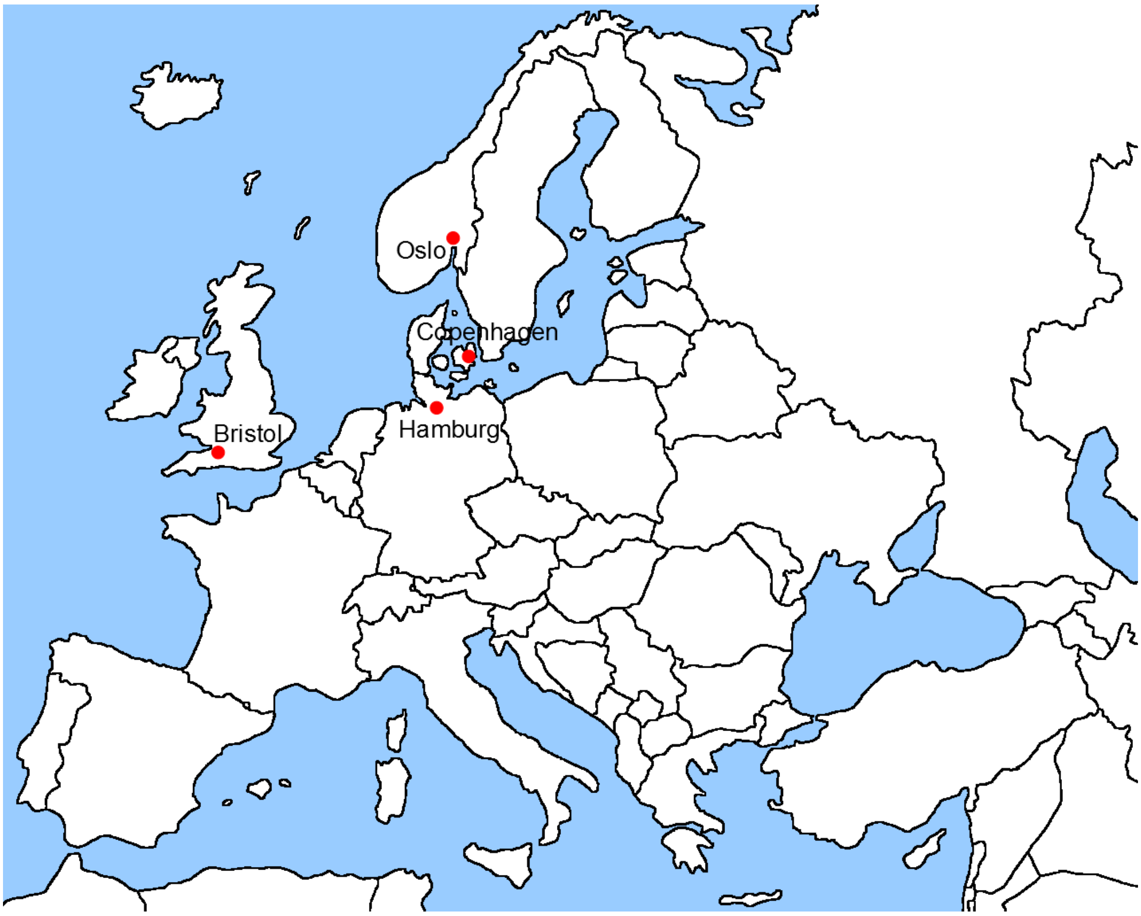

Figure 3.1: Location of the European Green cities: Bristol, Copenhagen, Hamburg and Oslo

Bristol, United Kingdom

Bristol City is a part of South West region with 1.1 million residents. In the last 10 years Bristol City's population has grown by 10% and the value of its economy has grown by 40% (Ec.europa.eu, 2016). In 2014 Bristol was named by Sunday Times the best place to live in the UK, and was the European Green Capital 2015 (Bristol.gov.uk, 2016; Ec.europa.eu, 2016)

Population: 442 500 (2015)

Households: 195 000 (2015)

Coordinates: 51°27′N 2°35′W

GDP/capita: US$ 37 300 (2016)

Area: 110 km^2 (2016)

Currency: Pound sterling

Copenhagen, Denmark

Copenhagen is the natural centre of the Øresund Region with the Øresund Bridge, a fixed link between Sweden and Denmark. Copenhagen was the European Green Capital 2014 and aims to be Carbon Neutral by 2025. The city is investing in renewable energy sources, retrofitting buildings with new kinds of insulation and constructing large onshore wind turbines (Copenhagen.com, 2016; Ec.europa.eu, 2016).

Population: 591 481 (2016)

Households: 292 926 (2016)

Coordinates: 55° 40' 33.9528'' N 12° 34' 6.0132'' E

GDP/capita: US$ 37 800 (2016)

Area: 86.40 km^2 (2016)

Currency: Danish Kroner

(Denmark.dk, 2016)

Hamburg, Germany

Hamburg is located along the Elbe River and is the second largest city. With 30 square metres of living space per person, Hamburg has the biggest average living space of all major cities in the world. As much as 14% of the city area is made up of green spaces and recreational areas. Hamburg has 2,302 bridges - more than Venice and Amsterdam combined. With over 90 consulates, Hamburg is the second only to New York City in this respect. As a trade centre, Hamburg has always been outward-looking, that has shaped the mentality of Hamburg's inhabitants. In the year 2000, the city was presented with the Energy Globe Award for its achievements in the areas of energy efficiency and climate protection. In February 2009, Hamburg was designated European Green Capital 2011 by the European Commission (Ec.europa.eu, 2016).

Population: 1 762 791 (2015)

Households: 965 000 (2015)

Coordinates: 53° 33′ 55″ N 10° 00′ 05″ E

GDP/capita: US$ 39 500 (2016)

Area: 755.3 km^2 (2016)

Currency: Euro

Oslo, Norway

Oslo is the capital and largest city in Norway and is one of the fastest growing cities in Europe. In 2003, Oslo received The European Sustainable City Award and in 2007 Reader's Digest ranked Oslo as number two on a list of the world's greenest, most liveable cities. The city of Oslo was a finalist for European Green Capital 2010 and European Green Capital 2011 (Ec.europa.eu, 2016; ssb.no, 2016; Visitnorway.com, 2016).

Population: 658 390 (2015)

Households: 330 000 (2015)

Coordinates: 59° 57′ N 10° 45′ E

GDP/capita: US$ 55 400 (2016)

Area: 454 km^2 (2016)

Currency: Euro

3.1 Trends and Pressures

The trends and pressure indicators for the four smart cities are listed in Tables: 3.1 – 3.4

Table 3.1: *Trends and pressures* in Bristol. In this table a short summary is provided of the key indicators of concern or great concern and how these affect Urban Water Cycle Services.

			0 1 2 3 4
Trends and pressures	**Social**	**1. Urbanization rate**	
		2. Burden of disease	
		3. Education rate	
		4. Political instability	
	Environmental	**5. Water scarcity**	
		6. Flood risk	
		7. Water quality	
		8. Heat risk	
	Financial	**9. Economic pressure**	
		10. Unemployment rate	
		11. Poverty rate	
		12. Inflation rate	

0	No concern	1	Low concern	2	Medium concern	3	Concern	4	Great Concern

The TPI for Bristol is 1.0. Political instability and unemployment rate are both a medium concern.

Table 3.2: *Trends and pressures* in Copenhagen. In this table a short summary is provided of the key indicators of concern or great concern and how these affect Urban Water Cycle Services.

			0 1 2 3 4
Trends and pressures	**Social**	**1. Urbanization rate**	
		2. Burden of disease	
		3. Education rate	
		4. Political instability	
	Environmental	**5. Water scarcity**	
		6. Flood risk	
		7. Water quality	
		8. Heat risk	
	Financial	**9. Economic pressure**	
		10. Unemployment rate	
		11. Poverty rate	
		12. Inflation rate	

0	No concern	1	Low concern	2	Medium concern	3	Concern	4	Great Concern

The TPI for Copenhagen is 1.1. There are no great concerns in the city. Water scarcity, flood risk, water quality and unemployment rate are a medium concern.

Table 3.3: ***Trends and pressures*** **in Hamburg. In this table a short summary is provided of the key indicators of concern or great concern and how these affect Urban Water Cycle Services.**

			0 1 2 3 4
Trends and pressures	**Social**	**1. Urbanization rate**	0
		2. Burden of disease	0
		3. Education rate	1
		4. Political instability	1
	Environmental	**5. Water scarcity**	1
		6. Flood risk	2
		7. Water quality	0
		8. Heat risk	1
	Financial	**9. Economic pressure**	0
		10. Unemployment rate	1
		11. Poverty rate	0
		12. Inflation rate	1

0	No concern	1	Low concern	2	Medium concern	3	Concern	4	Great Concern

The TPI for Hamburg is 0.7. Flood risk is a medium concern, and the rest of indicators are of low concern or no concern at all.

Table 3.4: ***Trends and pressures*** **in Oslo. In this table a short summary is provided of the key indicators of concern or great concern and how these affect Urban Water Cycle Services.**

			0 1 2 3 4
Trends and pressures	**Social**	**1. Urbanization rate**	1
		2. Burden of disease	0
		3. Education rate	1
		4. Political instability	1
	Environmental	**5. Water scarcity**	0
		6. Flood risk	1
		7. Water quality	2
		8. Heat risk	2
	Financial	**9. Economic pressure**	0
		10. Unemployment rate	1
		11. Poverty rate	0
		12. Inflation rate	1

0	No concern	1	Low concern	2	Medium concern	3	Concern	4	Great Concern

The TPI for Olso is 0.8. Water quality and heat risk are a medium concern for the city.

3.2 City Blueprint

The City Blueprint indicators and their scores for the four smart cities are listed in Table 3.5.

Table 3.5: List of City Blueprint indicators for Bristol, Copenhagen, Hamburg and Oslo

Category	No.	Indicator	Bristol	Copenhagen	Hamburg	Oslo
I	1	Secondary WWT	10	8.8	9.6	6.2
	2	Tertiary WWT	0	8.6	9.3	6.0
	3	Groundwater quality	7.4	5.7	6.4	9.8
II	4	Solid waste collected	5.6	0.0	1.6	3.6
	5	Solid waste recycled	6.6	9.3	7.5	9.1
	6	Solid waste energy recovered	4.8	9.5	4.3	9.3
III	7	Access to drinking water	10	10	10	10
	8	Access to sanitation	10	10	9.9	10
	9	Drinking water quality	10	9.2	10	10
IV	10	Nutrient recovery	10	0.0	0.0	0.0
	11	Energy recovery	10	8.8	9.6	5.0
	12	Sewage sludge recycling	10	7.9	9.6	6.2
	13	WWT Energy efficiency	10	9.0	10	5.0
V	14	Average age sewer	2.0	6.0	2.8	1.0
	15	Operation cost recovery	6.9	10	3.3	5.4
	16	Water system leakages	6.7	8.4	9.1	5.4
	17	Stormwater separation	5.0	1.2	7.6	6.4
VI	18	Green space	5.6	3.9	3.0	3.4
	19	Climate adaptation	9.0	8.0	10	7.5
	20	Drinking water consumption	4.9	9.8	9.7	6.4
	21	Climate robust buildings	6.0	6.0	10	7.5
VII	22	Management and action plans	8.0	8.0	10	7.0
	23	Public participation	8.1	8.1	5.8	9.0
	24	Water efficiency measures	9.0	9.0	10	5.5
	25	Attractiveness	10	10	10	9.5
		Blue City Index (BCI)	6.7	6.3	6.6	5.8

Categories: I – Water quality, II – Solid waste treatment, III – Basic water services, IV – Wastewater treatment, V – Infrastructure, VI – Climate robustness, VII – Governance

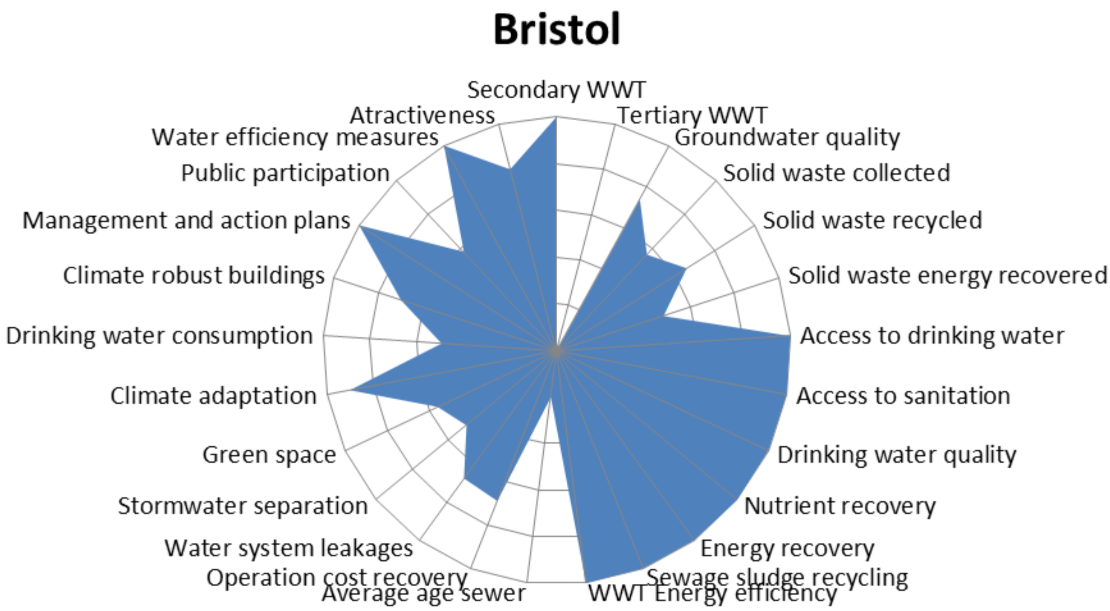

Figure 3.2: City Blueprint of Bristol. A score of 0 (inner circle) means that further attention is needed and a score of 10 is an excellent score (outer circle). The Blue City Index has a score of 6.7.

Bristol is performing excellent in Basic water services and Wastewater treatment categories. Tertiary waste water treatment is foreseen to be operational for 90% of waste water by 2017 (Krugerusa.com, 2016).

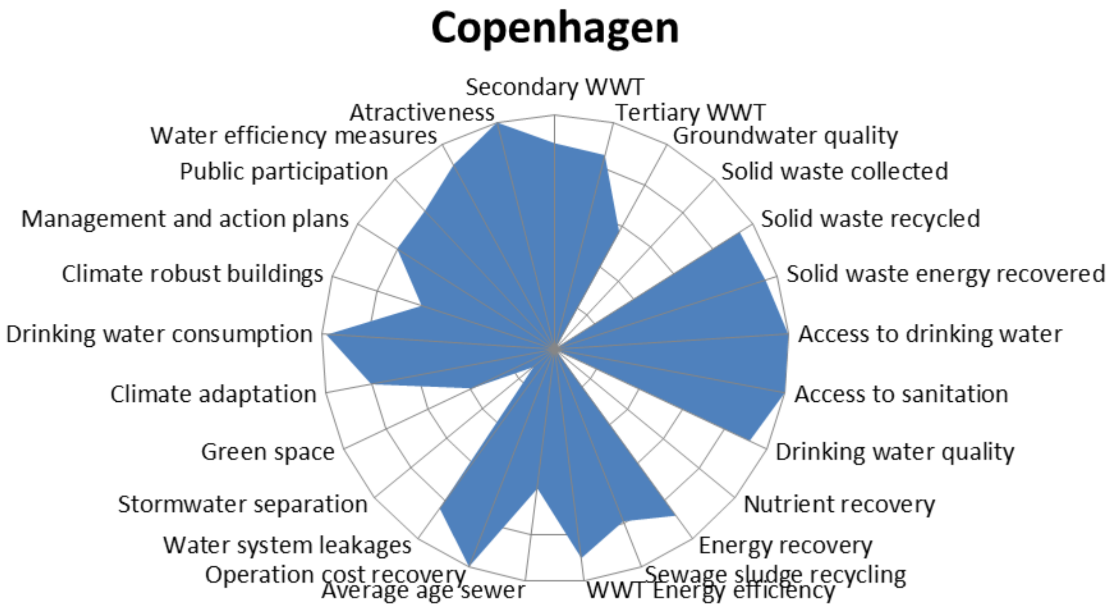

Figure 3.3: City Blueprint of Copenhagen. A score of 0 (inner circle) means that further attention is needed and a score of 10 is an excellent score (outer circle). The Blue City Index has a score of 6.3.

Copenhagen is performing well or very well in all seven categories. However, there are two indicators that need immediate attention in order for the city to become water wise: Solid waste collected and nutrient recovery.

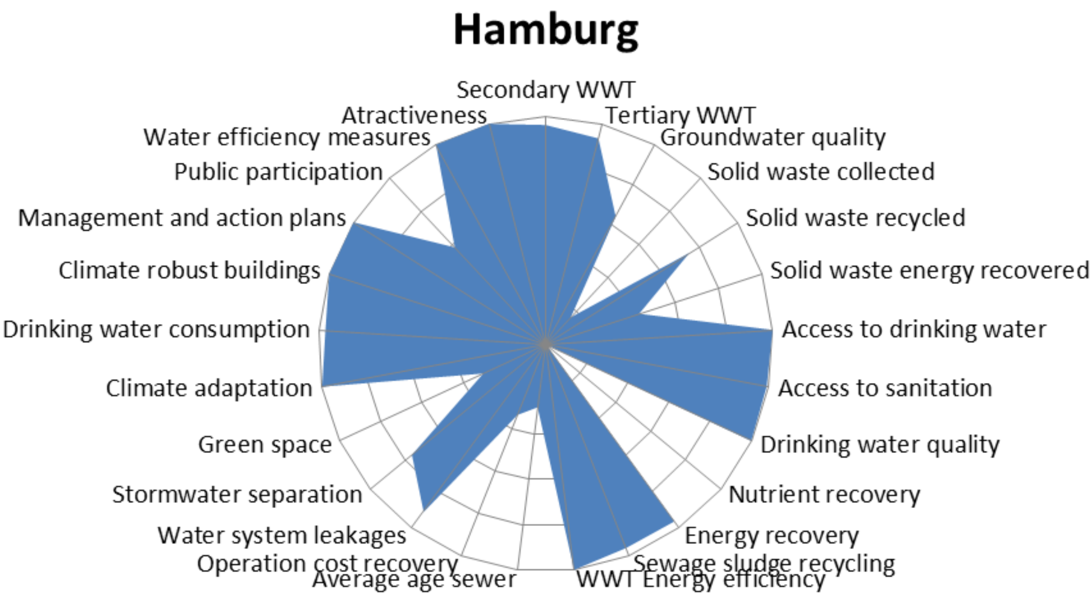

Figure 3.4: City Blueprint of Hamburg. A score of 0 (inner circle) means that further attention is needed and a score of 10 is an excellent score (outer circle). The Blue City Index has a score of 6.6.

City of Hamburg is performing well in all seven categories. However, two indicators: solid waste collected and nutrient recovery should be improved.

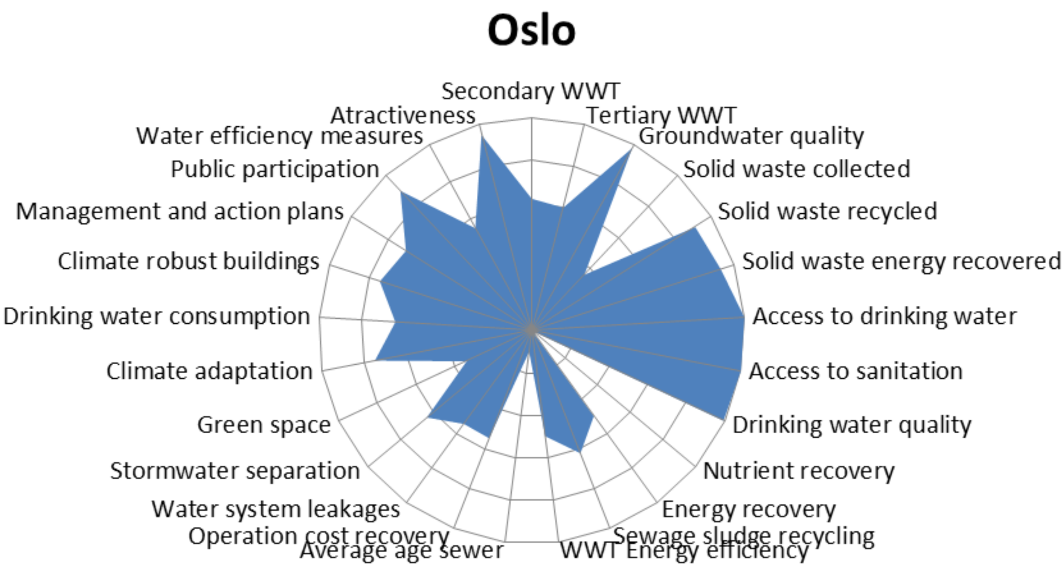

Figure 3.5: City Blueprint of Oslo. A score of 0 (inner circle) means that further attention is needed and a score of 10 is an excellent score (outer circle). The Blue City Index has a score of 5.8.

Oslo is performing well in all seven categories. However, there are two indicators that need immediate attention in order for the city to become water wise: nutrient recovery and average sewer age.

3.3 City Amberprint

The City Amberprint indicators and their scores for the four smart cities are listed in Table 3.6.

Table 3.6: List of City Amberprint indicators for Bristol, Copenhagen, Hamburg and Oslo

Category	No.	Indicator	Bristol	Copenhagen	Hamburg	Oslo
ENERGY	1	Carbon footprint	7.7	7.8		
	2	Fuel poverty	8.7	9.7		
	3	Energy consumption	9.0	9.7		
	4	Energy self-sufficiency	5.2	4.6		
	5	Renewable energy ratio	4.5	4.6		
	6	Energy efficiency plans	10.0	7.0		
	7	Energy infrastructure investment	4.5	8.1		
TRANSPORT	8	Commuting time	4.0	7.4		
	9	Use of public transport	5.1	4.4		
	10	Bicycle network	3.4	3.6		
	11	Transportation fatalities	10.0	10.0		
	12	Clean energy transport	10.0	10.0		
	13	Transport-related pollutions	8.9	9.5		
	14	Transport infrastructure investment	6.8	5.3		
ICT	15	ICT access	9.5	8.4		
	16	ICT use households	9.0	8.7		
	17	ICT use water utilities	8.0	9.0		
	18	ICT use energy utilities	8.0	10.0		
	19	ICT use transport	8.8	9.8		
	20	ICT use waste management	8.0	7.5		
	21	Digital public service	8.5	5.9		
	22	ICT infrastructure investment	9.2	4.8		
		Amber City Index (ACI)	7.4	7.2		

Comment:

This work was delayed due to the slow response by the Green City councils. A number of remedial actions have been undertaken. The information related to CBF was readily available from the previous work in the project. The information related to CAF was collected and confirm by Bristol and Copenhagen. However, there was no success in contacting Hamburg and Oslo.

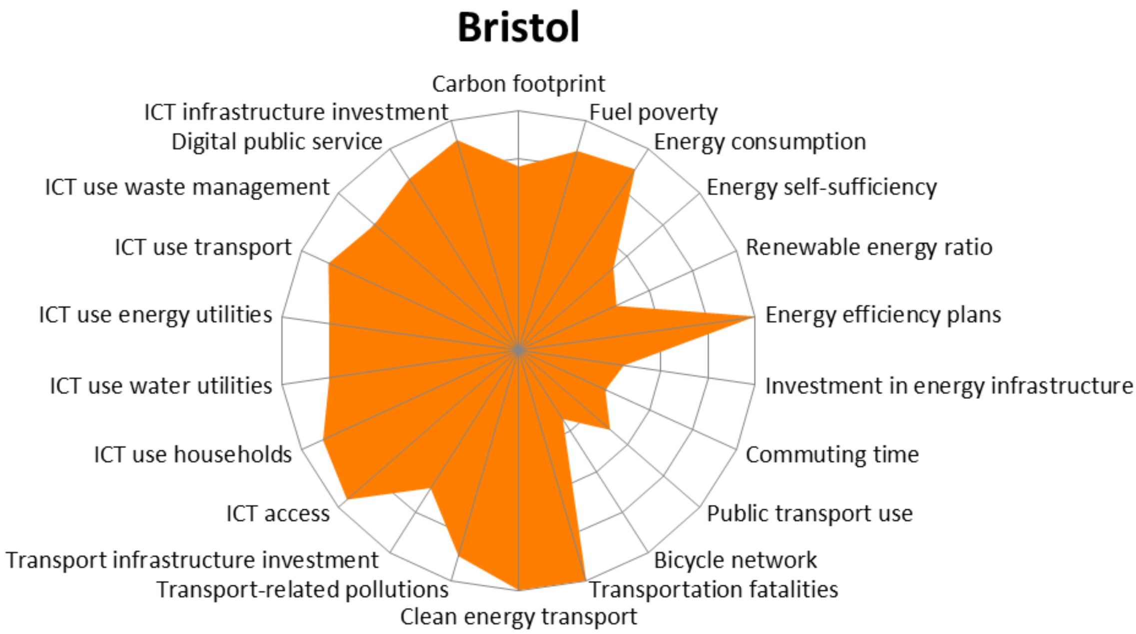

Figure 3.6: City Amberprint of Bristol. A score of 0 (inner circle) means that further attention is needed and a score of 10 is an excellent score (outer circle). The Amber City Index has a score of 6.7.

Bristol is performing very well in the ICT category. The city is investing in all infrastructures and working on improving public transport and bicycle network.

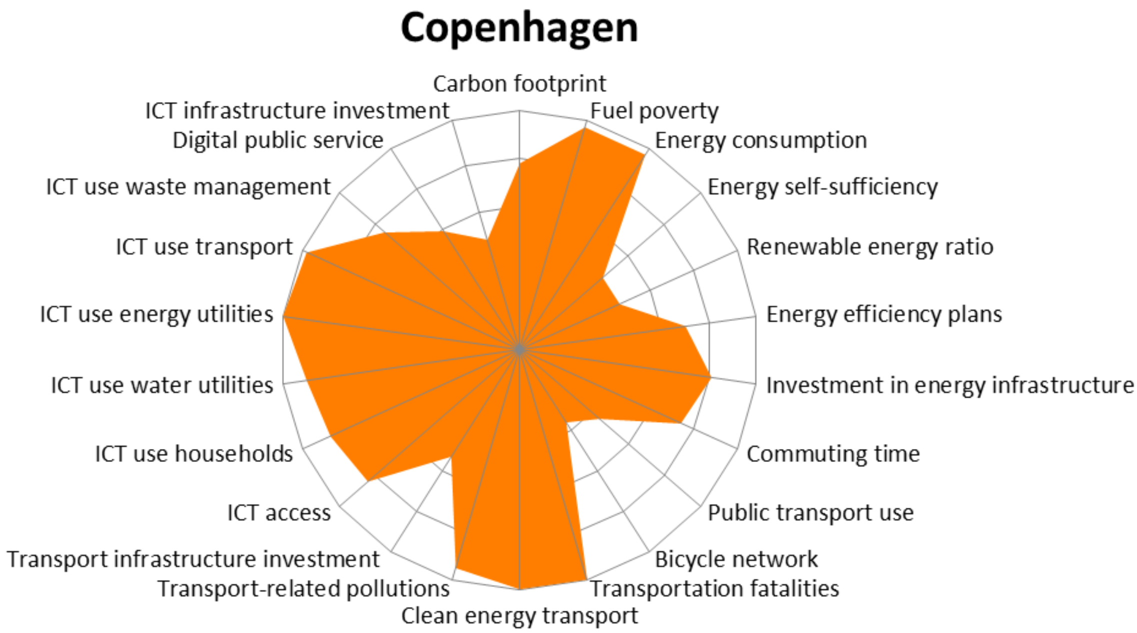

Figure 3.7: City Amberprint of Copenhagen. A score of 0 (inner circle) means that further attention is needed and a score of 10 is an excellent score (outer circle). The Amber City Index has a score of 6.3.

In Copenhagen cycling is the most popular form of transportation. However, in the assessment the score for bicycle network is relatively low (3.6) showing that meters of bicycle network per capita is lower than in other cities. The city is investing in clean energy transportation. ICT tools are widely used in the city.

4 Best practices

A process of how to share the best practices and learn from one another has been started and will be facilitated during this task.

4.1 Bristol

Bristol was named European Green Capital 2015. Some of the following best practices in water and waste management helped the city to get this award.

4.1.1 Bristol Green Doors

Social enterprise Bristol Green Doors, whose "open door" events showcase ordinary citizens homes that have had energy efficiency refurbishment. Supported by Bristol City Council it began in 2010 with 50 homes and 2,700 visitors of whom 70% were "more likely to install related solutions" after visiting the homes. It now holds regular events. The core purpose of this initiative is to run educational events to encourage, inspire, and enable domestic green refurbishment in the community (Bristolgreendoors.org, 2016).

Related City Blueprint Indicators are: 21. Climate robust buildings; 23. Public participation; 24. Water efficiency measures.

4.1.2 Advanced anaerobic digesters

Biomethane is produced at Bristol sewage treatment works by anaerobic digestion to contribute to the national natural gas network and for transport (Figure 4.1). A Bio-Bug (converted VW Beetle) is powered by the gas and used to promote eco awareness (Ec.europa.eu 2016).

Figure 4.1: Anaerobic digestion of food waste (Geneco.uk.com, 2016) and Britain's first bus powered using these processed (BBC News, 2016a)

GENeco, a subsidiary of Wessex Water, launched the UK's first bus to be powered by gas generated from sewage and inedible food waste in 2014 (BBC News, 2016a), and it has been providing a regular service in the Bristol area. In 2016 another 10 Bio-Buses could be in operation in Bristol and further 10 to be running within the area by 2019 (Geneco.uk.com, 2016).

Related City Blueprint Indicators are: 11. Energy recovery; 12. Sewage sludge recycling

4.1.3 Mechanical Biological Treatment (MBT) Plant

Since 2013 100% of residual waste has been treated in 250kt MBT facility. The key output of the facility is Refuse-Derived Fuel (RDF) which is exported to the Netherlands for use in district heating schemes. Additionally, the UK's first commercial-scale 13MWe energy recovery was built in 2014 alongside the existing MBT facility. The plant was delivered in two phases, each of 6.5MWe. Each of the two phases consists of eight Syngas Products units and combustors feeding one of two single boilers and steam turbines. Each phase processes 60,000 tonnes of RDF per year. Discussions are taking place to supply heat off-site (Syngas-products.com, 2016).

Related City Blueprint Indicators is: 6. Solid waste energy recovery

4.1.4 Wetland management initiatives

In 2012 Local Nature Partnership (LNP) Status was awarded to the West of England (which Bristol City Council is one of the partners) by the UK government. LNPs provide help to local areas to manage the natural environment and to include its value in local decisions for the benefit of nature, people and the economy (Bristol.gov.uk, 2016; Gov.uk, 2012). Bristol City Council is working on:

- Identification of wildlife network sites suitable for provision of priority habitat creation/restoration projects and development of implementation programme;
- Development of opportunities for biodiversity restoration within Blaise Strategic Nature Area;
- Identification of sites for re-creation/restoration of species rich grassland and development of programme for implementation towards target of 3 hectares;
- Seek to develop a programme of habitat management on Bristol Sites of Nature Conservation Interest (SNCI) open water habitat to bring into favourable conservation status;
- Development and implementation of enhancement plans for selected rivers through Area Green Space Plans and working with local communities;

Related City Blueprint Indicators are: 19. Climate adaptation;18. Green space; 25. Attractiveness;

4.1.5 Other open spaces initiatives

19% of green and blue space in Bristol is not a part of Wildlife Network space. Plans for non-protected areas include:

- In Bristol, there are 108 hectares of allotments that need biodiversity management. Their holders are encouraged in different ways, e.g. by activities, or surveys, to take action for wildlife
- Development a specification for species rich grass green roofs, and promotion through the planning system
- Identification of strategic woodland corridors and opportunities to strengthen them by planting more trees; consideration to use available areas of public open space and street trees, using species with value for wildlife
- Wildlife enhancements for cemeteries based on audits.

Reflecting the importance of ‘open mosaic habitat on previously developed land’ as detailed in the Bristol Biodiversity Action Plan, Bristol City Council is starting work on its first new land on the site in South Bristol (Bristol.gov.uk, 2016; Ec.europa.eu 2016).

Related City Blueprint Indicators are: 18. Green space; 25. Attractiveness

4.1.6 Sustainable Drainage Systems (SUDS)

In the UK use of SUDS is required by the Government on all developments wherever possible. Floods are causing, on average, £270 million of damage every year. SUDS are used to help with existing overloaded systems and will help to accommodate future growth. There are three pillars of SUDS:

- Minimise water runoff QUANTITY
- Improve water QUALITY

– Provide AMENITY and biodiversity.

Concrete block permeable paving (CBPP) is the most versatile SUDS technique, which addresses both flooding and pollution issues (Marshalls.co.uk, 2016). There are three CBPP systems:

– Full infiltration, where all the water falling onto the pavement infiltrates down through the constructed layers below, see Figure 4.2. Some of the water will be temporarily retained in the permeable sub-base layer before it passes through to the subgrade layer (ground). This is a very economical solution as no pipes or gullies are needed as no water is discharged into conventional drainage system (Marshalls.co.uk, 2016).

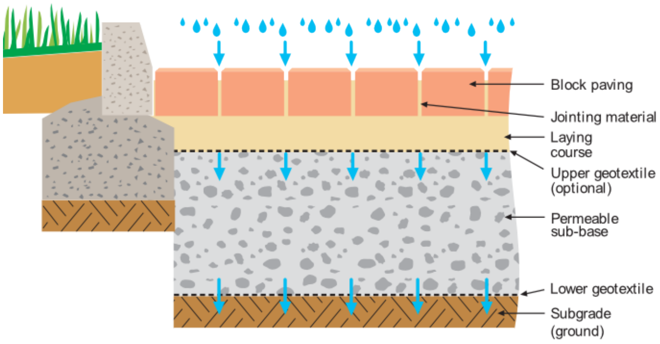

Figure 4.2: Full infiltration system (Paving.org.uk, 2016)

– Partial infiltration, where outlet pipes are connected to the permeable sub-base layer (Figure 4.3). This system is used when the existing subgrade (ground) is not capable of absorbing all the water. The excess water is drained to other drainage devices such as ponds, swales, sewers or watercourses (Marshalls.co.uk, 2016).

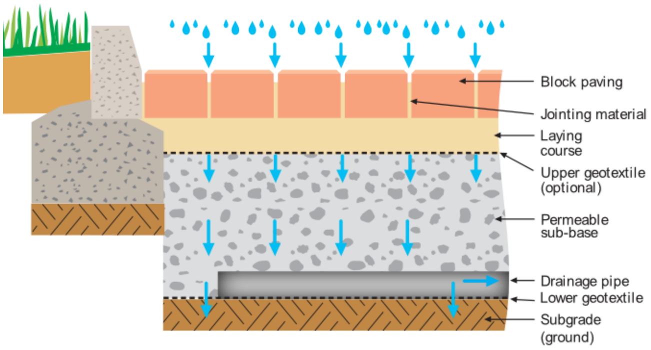

Figure 4.3: Partial infiltration system (Paving.org.uk, 2016)

– No infiltration, where the water is completely captured (Figure 4.4) and eventually released into the subgrade (ground). In this solution an impermeable, flexible membrane is placed on top of the subgrade level and up the sides of the permeable sub-base to form a storage tank. The water is transmitted via outlet pipes constructed through the impermeable membrane to other drainage devices such as ponds, swales, sewers or watercourses. This system is particularly suitable for contaminated sites, as it prevents pollutants from being washed further down where they could reach groundwater (Marshalls.co.uk, 2016).

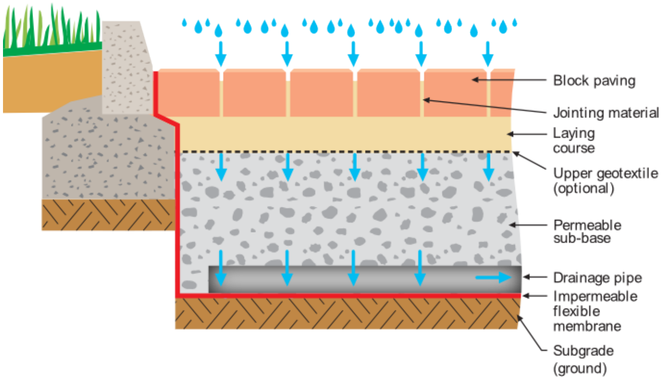

Figure 4.4: No infiltration system (Paving.org.uk, 2016)

In Bristol Business Park (Figure 4.5) where frequent flood issues during heavy rain. Therefore, car parking areas were converted in 2003 into a combination of impermeable concrete block paving and CBPP. Due to poor permeability of the subgrade (ground) in the area no infiltration system was introduced. Total area of CBPP is 6000 m^2. Water is drained to the CBPP and discharged into swales which are subsequently discharged through wet detention ponds into the off-site watercourse (Marshalls.co.uk, 2016).

Figure 4.5: Bristol Business Park (Paving.org.uk, 2016)

Bristol City Council started introducing SUDS in Home Zones. In the Dings Home Zone the existing combined sewer system was working at full capacity. In 2005 no infiltration CBPP system was used for attenuation and treatment before discharge to watercourse (Marshalls.co.uk, 2016).

Other examples of SUDS used in Bristol are:

- Sedum mat green roofs, which cover six units at the centre of the Ashley Vale self-built site (Figure 4.6). Each 70m^2 roof is covered in three layers of special roofing felt to inhibit root growth. The roofs were delivered as pre-compiled tile-like units. Each of these tiles consisted of a 40mm layer of recycled sponge, covered in a 40mm layer of reclaimed crushed building aggregate. Both of these components were impregnated with nutrients and covered in a layer made up of five varieties of sedum plants. The green roofs retain heat in winter and keep the buildings cool in summer. They were installed in 2007 (Bristol.gov.uk, 2016).

Figure 4.6: The green roofs at the centre of the Ashley Vale self-built site (Bristol.gov.uk, 2016)

- Sedum greenroof. One example is retrofitted onto an existing flat concrete roof of the At-Bristol Centre (Figure 4.7). Since 1999 it has been providing thermal insulation and brought greater biodiversity in the city centre. Volunteers from the local community maintain the roof, re-plant different varieties of sedum and weeding providing attractive scenery for the conference facilities. Another example is Barton Hill School where the green roof is approximately 900 m^2 (Figure 4.8). The project was completed in October 2007. The roof is timber decked, with a Rhepanol root resistant membrane laid over it, followed by the green roof system. In this solution the green roof consists of a recycled HDPE drainage layer, 70mm substrate and is both seeded and plug planted with sedums (Bristol.gov.uk, 2016).

Figure 4.7: The sedum greenroof at the At-Bristol Centre (Bristol.gov.uk, 2016)

Figure 4.8: Two adjacent green roofs covering Barton Hill School (Bristol.gov.uk, 2016)

- Permeable paving using the Netpave 50 system discharging into swales was used at Bristol International car park (Figure 4.9). 10,000 m^2 built in 2005 offers up to 1,000 parking spaces. At the bottom there is an impermeable membrane which is covered by geotextile layer. On top of which is a sub-layer consisting of 5-45 mm stones. This layer is covered by another geotextile layer that is under the Netpave 50 flexible surface filled with aggregate and bedded on 20 mm of the same aggregate. This system can be filled with gravel or a growing medium and seeded. Surface water runoff is directed to perforated pipes that are bedded into the sub base layer (which filters out the pollutants). These pipes are subsequently connected to a silt trap and to swales (Bristol.gov.uk, 2016).

Figure 4.9: Bristol International Airport car park covered in permeable paving using the Netpave 50 system discharging into swales (Bristol.gov.uk, 2016)

- The concrete roof (with area of 500m^2) of Bristol University Auditorium was firstly fitted with a blue roof: isolating membrane, insulating layer and waterproofing membrane. To provide required attenuation, on top of a protective matt two 50mm deep plastic crate layers were installed. Additionally, to prevent sediment ingress, a filter sheet was installed (Figure 4.10).

Secondly, a green roof was fitted on top with the soil and drainage matrix and seeded planting media. The main purpose of the green roof is to reduce surface water runoff rate, and the blue roof should provide water runoff storage volume. The modular design of both roofs allows easy disassembly if required (Bristol.gov.uk, 2016).

Figure 4.10: Blue and green roof at Bristol University Auditorium (Bristol.gov.uk, 2016)

- The Dings' combined sewer systems were at capacity. Permeable pavement was installed to avoid costly underground storage tanks. The full infiltration system allows runoff into a stone sub-base which is filtrated and slowly released in a controlled matter (Bristol.gov.uk, 2016).
- In Hartcliffe Children's Centre (Figure 4.11) a green roof was installed to protect from heat build-up, reduce the noise during rainfall and reduce the peak runoff from the site (Bristol.gov.uk, 2016).

Figure 4.11: Hartcliffe Children's Centre (Bristol.gov.uk, 2016)

- Redland Green School in Bristol uses multiple SUDS techniques: permeable surfaces, green roof predominantly planted with sedum, infiltration techniques to minimise off-site runoff, swales with weirs to control the rate of run-off and retention to a watercourse for additional flow (Figure 4.12). The natural slope of the site was used in the final design of the school. The main benefits of using these solutions are provision of outdoor classroom for students, enhancement of the biodiversity in the area and managing runoffs (Bristol.gov.uk, 2016).

Figure 4.12: Redland Green School in Bristol (Bristol.gov.uk, 2016)

Related City Blueprint Indicators are: 17. Stormwater separation 19. Climate adaptation; 21. Climate robust buildings; 22. Management and action plans; 25. Attractiveness

4.1.7 City to Sea campaigns

It brings together local environmental campaigners, consultants and marine biologists that want to address plastic pollution at a city level. The main objective is to reduce the amount of plastic litter flowing from Bristol into the Severn Estuary. To achieve this goal phasing out single-use plastics and creating a replicable model that can be shared with other coastal and river based cities is proposed (CitytoSea.org.uk, 2016).

- Refill Campaign - a practical tap water campaign that aims to make refilling bottles as easy, convenient and cheap as possible by introducing refill points on every street. Cafes, restaurants, shops, hotels, galleries and businesses that want to participate in the project, put a sticker on their window (Figure 4.13), which shows that anybody can come in and refill their bottle for free.

Figure 4.13: Sticker for Refill Campaign (CitytoSea.org.uk, 2016) and Pop-Up Water bar at Bristol Balloon Fiesta (Twitter.com, 2016)

The outcome of the campaign is plastic waste reduction, but also raising awareness about the fact that tap water is of better quality than bottled water (Refillbristol.org.uk, 2016). The website offers a possibility to: check where the closest Refill point is, register as a Refill station, buy Refill bottles and learn about impacts of plastics. Bristol Water is involved in the campaign and contributing by installing new and refurbishing old water fountains. Bristol Water also created a Pop-Up Water bar which plays a role of an extra refill station at festivals and events across the city (Bristolwater.co.uk, 2016). People can pour themselves a pint of water and buy reusable stainless steel bottles.

- #SwitchtheStick – a campaign that aims to put an end to cotton bud plastic pollution by working on three levels: (i) encouraging consumers to change their buying habits and switch from plastic to paper-stem cotton buds; (ii) working with major UK retailers to stock paper-stem buds and phase out sales of plastic cotton buds; (iii) lobbying UK manufacturers to stop the production of plastic cotton buds and switch to paper-stems (CitytoSea.org.uk, 2016). It is estimated that 500,000 plastic buds a week get flushed down the toiled only in Thames Water region. These buds end up in river banks and coastlines polluting the environment.

Related City Blueprint Indicators are: 4. Solid waste collected; 18. Green space; 19. Climate adaptation; 23. Public participation; 25. Attractiveness

4.2 Copenhagen

Copenhagen was the European Green Capital 2014. It aims to be carbon neutral by 2025 and some of the following best practices will contribute to achieving this goal.

4.2.1 Tåsinge Plads – Copenhagen's First Climate-Resilient Urban Space

Tåsinge Plads is Copenhagen's first climate change-adapted urban space (Figure 4.14). The square (7500 m^2) is a green oasis, which both creates a place for the neighbourhood's residents to meet and diverts and percolates rainwater from roofs and squares locally to keep it away from the sewers (International.stockholm.se, 2016; Klimakvarter.dk, 2016).

Figure 4.14: Tåsinge Plads (Klimakvarter.dk, 2016)

Related City Blueprint Indicators are: 18. Green space; 19. Climate adaptation; 21. Climate robust buildings; 25. Attractiveness

4.2.2 Efficient Heat and Domestic Water Supplies

The City of Copenhagen will, together with Copenhagen Energy and others, create incentives for totally upgrading heat and domestic water supplies in Copenhagen before 2025. Expectations are that the total heat consumption in Copenhagen can be reduced by 10% if heat and domestic water supplies in Copenhagen are increasingly regulated and adjusted to demand. Remote meter reading of heat consumption can be used to identify industrial plants with unusually high consumption.

Through field work, inefficient plants will be regulated and optimised, so that temperatures can be adjusted for maximum efficiency (Stateofgreen.com, 2016).

Related City Blueprint Indicators are: is. Water efficiency measures

4.2.3 Monitoring energy and water consumption

Nordhavn, a harbour area 2.5 miles from Copenhagen's urban centre, will be used as a pilot project for monitoring and publication of energy consumption data in buildings. It is planned to monitor energy and water consumption in City of Copenhagen buildings by remote meter reading. This data will be used by the City Administration, in conjunction with relevant players, to optimise and innovate the city's digital infrastructure (Stateofgreen.com, 2016).

Related City Blueprint Indicators are: 20. Drinking water consumption; 21. Climate robust buildings; 22. Management and action plans; 24. Water efficiency measures

4.2.4 Nordhavn Project

Nordhavn's strategy is based on six themes that were identified by the City of Copenhagen for the sustainable city of the future:

- "islets and canals" to connect inhabitants with natural landscapes;
- "identity and history" to highlight landmarks and link future developments to past land use;
- "five-minute city" to guarantee no more than a five-minutes-walk to public transportation;
- "blue and green city" to integrate water and green landscapes and offer opportunities for a multitude of activities;
- "energy supply of the future" to emphasis local renewable energy sources and collective solutions.

Nordhavn Project (Figure 4.15) will serve as a testing ground for partnerships between government institutions, corporations, utility companies, and universities (C40.org, 2016).

Figure 4.15: Artist's visualisation of the Nordhavn Project at completion (C40.org, 2016)

Related City Blueprint Indicators are: 18. Green space; 25. Attractiveness

4.2.5 Remote cooling

Copenhagen Energy has established remote cooling systems for businesses on Kongens Nytorv (a central old square where institutions such as the Royal Theatre, the Charlottenborg Academy and the D'Angleterre Hotel are located) and Rådhuspladsen (The City Hall Square) and plans to establish remote cooling at the University of Copenhagen, the Panum Institute and Rigshospitalet (Stateofgreen.com, 2016).

Remote cooling is more energy-efficient when replacing individual compressor cooling systems in commercial buildings. In winter, seawater is used for cooling and in summer, cooling comes from steam from the power plants and via electrically-powered refrigeration compressors. The City of Copenhagen is assessing the energy efficiency, the economy and the environmental benefits of remote cooling (Stateofgreen.com, 2016).

Related City Blueprint Indicators are: 19. Climate adaptation; 21. Climate robust buildings;

4.2.6 District Heating Supplied by Waste Heat

The district heating grid now covers 98% of the demand for heating in Copenhagen. It uses waste heat from refuse incineration plants, and combined heat and power plants (CHPs). By cogenerating heat and power, the system is almost twice as efficient as compared to separate production. This results in significant environmental benefits, but has also secured cheap heating that is half as expensive as gas-fired or oil central heating. Part of the funds saved from the purchase of fossil fuels is used in Copenhagen which helps local business and employment. The goal is to make district heating carbon neutral by 2025 and for Copenhagen to help secure the generation of renewable surplus power. Copenhagen will be a net exporter of green energy, thus reducing coal-based power generation outside the City of Copenhagen area (C40.org, 2016; Stateofgreen.com, 2016).

Related City Blueprint Indicators are: 19. Climate adaptation; 21. Climate robust buildings;

4.3 Hamburg

The city of Hamburg as the European Green Capital of 2011 has some of the most advanced practices towards water and waste management. Some of them are mentioned in the following sections.

4.3.1 Cooperation between the water and waste public utilities in Amsterdam and Hamburg

This best practice was originally described in deliverable D2.3 as follows:

Amsterdam and Hamburg depict the situation where cooperation between local, sector-specialised municipally owned utilities was preferred over fusion.

Amsterdam focuses on the sustainable management of urban resources with a circular economy approach. The city is served by three different municipally owned utilities for water (Waternet), energy and waste (AEB Amsterdam), and public transport company (GVB). Amsterdam fosters cooperation between these utilities, instead of integrating them in one organisation.

The circular economy approach has proven beneficial in Amsterdam, especially Waternet's initiative on the integrated water lifecycle management. The transition enabled cost savings and operation efficiency. Existing practices include material recovery from wastewater, energy recovery from water cycle, incineration of biogas and sludge at waste to energy plant, waste to energy and waste to material etc. Many of the projects are carried out under the cooperation of different actors. More generally, the circular economy was estimated to represent for the Netherlands an economic benefit of €7.3 billions and the creation of 54,000 jobs (Bastein et al. 2013).

The reason for choosing a cooperation approach rather than integration is that the assessed synergy advantages would not exceed the reorganization costs for Amsterdam. The city also highlighted the importance of transparency in sharing information in the frame of its transition plan. Amsterdam is working on ICT to achieve its goals. The normalization, access, security, and communication of data are discussed as part of a broader agenda. Water pollution issues are also taken into account in the cooperation initiatives.

Hamburg provides a leading example of sector integration, principally encompassing water and wastewater. But it also now includes an element of energy with wastewater as a source of energy. Hamburg is the second largest city in Germany, with a population of 1.7 million, rising to 5 million including the total metropolitan area. Hamburg was an independent city state for centuries, and is now one of the 16 German Federal States (Länder). Hence it retains a tradition of independence and self-sufficiency, and enjoys the same powers as a regional Land.

In Hamburg, sector integration starts with governance. In 2006, the long established publicly owned Hamburg Waterworks (HWW) and Hamburg Sewage Works (HSE) merged to form the horizontally organised Hamburg Wasser group (Hamburg Water Group). The integrated corporate structure allows for the utilisation of many synergetic aspects for the benefit of the customers (the citizens and industry). The model maintains, however, a sufficient separation of structures to enable compliance with federal tax regulations.

Important advantages of the merger include: standardised organisational structures, joint human resources development, joint asset management, a stronger procurement process, a uniform ICT landscape, combined accounting for customers of water and wastewater services, and improved coordination of infrastructure installation and maintenance.

Hamburg Wasser supplies 2 million people with 320,000 m^3/day (average). Efficient management is represented in the low leakage loss rate of 5%, well below the European average, but similar to other German cities. Wastewater management is progressive. Sewage sludge is recycled via a sludge dewatering and drying plant as well as a sludge incineration plant with recovery of energy by a gas and steam turbine.

The integration of sectors is further streamlined by the creation of a wholly owned subsidiary consulting company, Consulaqua. This means a common team of expert engineers support both sectors, and in a strong position to identify and maximise the potential synergies.

Hamburg's innovative approach to sector integration (Van Leeuwen and Bertram, 2013) is embodied in the new residential development of Jenfelder Au (currently under construction) in the east of Hamburg which will incorporate the new Hamburg Water Cycle concept. In the 35 hectare development, 570 apartments will be fitted with water-saving vacuum sanitation technology (saving 7.3 m3/pers/yr) and separate wastewater collection, drainage and treatment systems. The black water stream will be used for biogas energy generation. The grey and storm water streams will be treated separately using a new and simplifies approach. Rainwater run-off will supply surface water features and grey water will be used for garden irrigation.

Related City Blueprint Indicators are: 5. Solid waste recycled; 6. Solid waste energy recovered; 10. Nutrient recovery; 11. Energy recovery; 12. Sewage sludge recycling; 14. Average age sewer; 16. Water system leakages; 22. Management and action plans; 24. Water efficiency measures

4.3.2 Reduction of packaging waste

The city of Hamburg announced in February 2016 in the "Guide to Green Procurement" (Hamburg.de, 2016) a ban on buying "certain polluting products or product components" with council money (BBC News, 2016b). They include:

- Equipment for hot drinks in which portion packaging is used was singled out with the emphasis on "Kaffeekapselmaschine" – "Coffee Capsule Machine" that often contain aluminium.
- Mineral water, beer and soft drinks in disposable packaging (excluding cartons, tubular bags and films stand-up pouches).
- Disposable tableware and utensils in cafeterias and canteens (if appropriate conditions may be adopted by districts).
- Chlorinated cleaners and air fresheners as these pollute the wastewater and can cause allergic reactions.

- Devices for heating (except necessary heating for winter measures) and for cooling the air space outside of enclosed spaces (e.g. "gas patio heaters", comparable electric radiators, air conditioners), since they increased relative energy requirements.
- Heavy metal based paint colorants because they pollute the environment.

All of these contribute to increased resource consumption and waste generation.

Related City Blueprint Indicators are: 4. Solid waste collected; 19. Climate adaptation; 21. Climate-robust buildings

4.3.3 Emissions-based port fees

In July 2011 Hamburg Port Authority introduced a discount for environmentally friendly ships. The aim is to reduce the emissions of harmful substances caused by ships. The Environmental Ship Index (ESI) is used for that purpose. It takes into account emissions of carbon dioxide, sulphur oxides and nitrogen oxides (Ec.europa.eu 2016).

Related City Blueprint Indicators are: 22. Management and action plans; 25. Attractiveness

4.3.4 Companies for Resource Protection

The initiative “Companies for Resource Protection” supports companies that want to engage in investment projects and helps them to overcome existing problems. This programme offers combination of financial, advisory and practical support. Moreover, the State Ministry of Urban Development and the Environment started cooperation with partners from technology, academia the private sector and craft trades, to establish a network of experts from different fields to encourage the exchange of knowledge about savings opportunities.

Funding is available for the installation of technology that will help to ease the burden on resources and the climate. The amount of funding available is determined by the environmental benefit the technology produces, e.g. a lower consumption of water, energy or raw materials or reduced carbon emissions. Thanks to this programme approximately 163,700 tonnes of carbon emissions and 26,500 tonnes of waste are avoided each year, and 712,300 cubic metres of water are saved annually (Ec.europa.eu 2016).

Related City Blueprint Indicators are: 4. Solid waste collected; 23. Public participation; 24. Water efficiency measures

4.3.5 The recycling offensive

Hamburg implemented recycling offensive that is an important contribution to climate protection and conserving resources. It works on two levels: firstly, the total volume of waste is significantly reduced through recycling, secondly, valuable raw materials are returned to the production cycle. Hamburg saves around 1 million tonnes of CO_2 a year through recycling and waste management. Projects to further reduce CO_2 emissions include modifying raw material collection from private households, motivating the housing industry, intensifying public information campaigns and adjusting legal frameworks. Currently, Hamburg is regularly collecting and recycling old paper, glass, plastics, organic and green waste (Ec.europa.eu 2016).

Related City Blueprint Indicators are: 4. Solid waste collected; 5. Solid waste recycled

4.3.6 The Innovative HAMBURG WATER Cycle®

The HAMBURG WATER Cycle® (HWC) concept (Figure 4.16) provides a holistic approach to both sanitation needs and the energy supply in urban areas. In the adapted approach, the areas of water and energy infrastructure become interdependent, simultaneously protecting water resources and utilizing wastewater to produce energy. HWC enables to close the material cycles directly in the residential environment (Hamburgwatercycle.de, 2016).

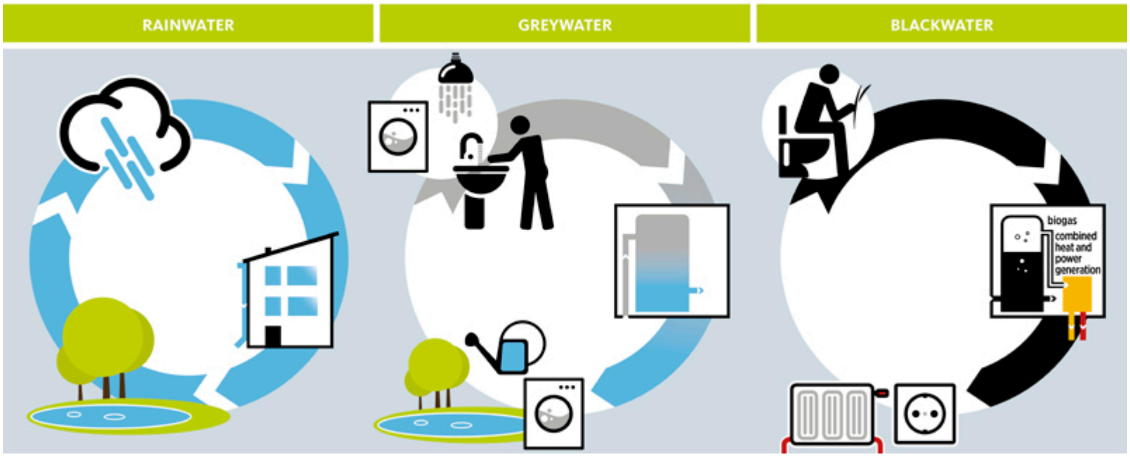

Figure 4.16: The three loops of the HAMBURG WATER Cycle® concept (Hamburgwatercycle.de, 2016)

The most important in the HAMBURG WATER Cycle® is the separate treatment of the different wastewater streams, the so-called partial flow treatment (Figure 4.17). Stormwater, wastewater from the toilet, and wastewater from the kitchen and bathroom (when using the dishwasher or washing hands for example) are separately collected and then separately treated.

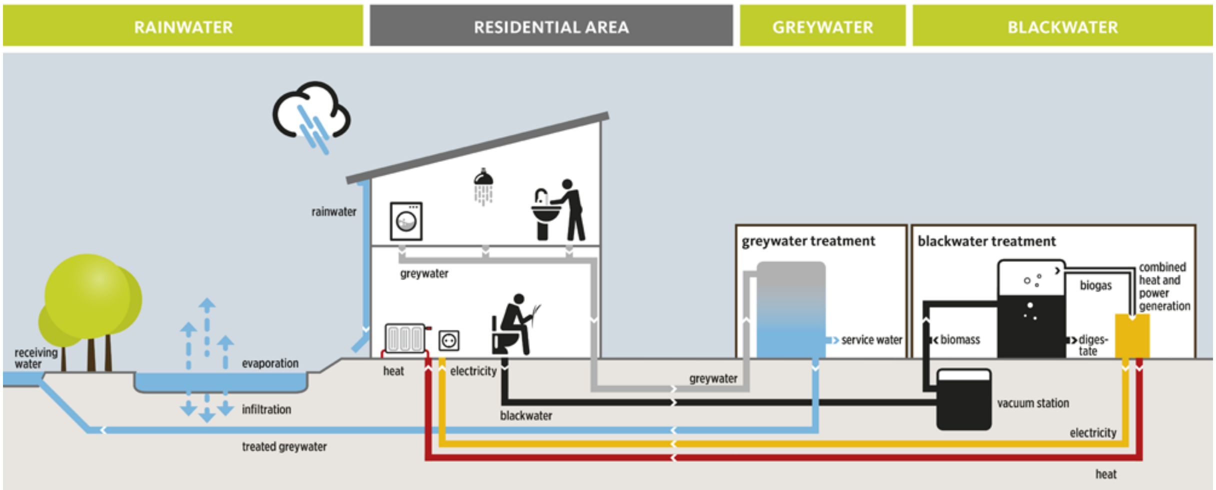

Figure 4.17: Separation of domestic wastewater for energetic use (Hamburgwatercycle.de, 2016)

Related City Blueprint Indicators is:10. Nutrient recovery; 11. Energy recovery; 17. Stormwater separation; 21. Climate robust buildings.

4.4 Oslo

The city of Oslo has a number of best practices and water and waste management.

4.4.1 Integrated Waste Management System

Oslo was mentioned in D2.3 as follows:

The developed system, based on the Waste Management Hierarchy, consists of an integrated waste management process concentrated on waste sorting and recycling. It is considered one of the most advanced systems for source separation of household waste and waste-to-energy working together.

In order to minimize the incineration and landfill of waste, different waste management systems are being developed concentrating on the behavioural habits of citizens and their sensitization. In consequence, collaboration with different local/regional bodies, voluntary organisations, awareness raising campaigns and tools as ICT are used to implement the strategy. Besides, the city is promoting the installation of pneumatic waste collection systems and the "producer pays" principle.

In Oslo, household waste is sorted by citizens into various fractions. The city has three large recycling stations, ten local recycling station and around 50 environmental waste stations located at gasoline stations. The distribution of recycling and waste stations has been defined taking into account the optimization of waste transport. The most recent recycling plant, which opened in 2014, is one of the most automatized waste sorting plants in Europe and uses several waste separation solutions based on sensor technology. This is also a clear example of the existing relationship between the implemented technology and ICT.

Two waste-to-energy plants incinerate residual waste, with a capacity of 410,000 tonnes of waste per year. Methane gas from the landfill is collected and delivered to the Waste-to-Energy plant. The energy is used for district heating (hot water) and electricity and meets the need of 85,000 homes. Organic waste is treated in biogas plants where the biogas is transformed into fuel for city buses. The newest biogas plant opened in 2013 and uses patented technology based on a Thermal Hydrolysis Process. The plant has the capacity to treat 50,000 tonnes/year of waste and can produce biogas to cover the fuel demand of 135 busses and bio fertilizer. This is an example of a state-of-the-art waste-to-energy plant in Norway. The implemented Waste Management System also implies a significant reduction of the waste transport as the 94% of waste is diverted from landfill.

The main results of the system according to data obtained in 2011 and 2013 are (Katsenis, 2011; C40, 2015; Depotech, 2014; European Sustainable Cities platform, 2015) are:

- Average amount of waste per inhabitant: 366 kg/year (Initial value in 2004: 401 kg/year)
- Amount of residual waste: 170 kg/year (Initial value in 2004: 244 kg/year)
- Tonnes of household waste collected: 240,000. 1% of it was reused, 33% recycled, 60% energy recovered and only 6% went to landfill.
- Energy production for district heating: 840GWh per year.
- Electricity generation: 160GWh per year.

Total cost: approximately 85 million euro. The corresponding income was around 100 million euro. The city inhabitants pay a mandatory fee in order to finance the waste service.

Average cost per inhabitant: 125€/year

Related City Blueprint Indicators is: 4. Solid waste collected; 5. Solid waste recycled; 6. Solid waste energy recovered

4.4.2 Renewable shore-based electricity for ships when docked in Oslo

Another interesting measure with potential for replication in other coastal cities throughout Europe is that the City of Oslo has ensured that ships run on renewable shore-based electricity, instead of fossil fuels, when docked in Oslo. This not only saves 3,000 tonnes of CO_2 annually, but can also help improve the air quality in the region. (Ec.europa.eu 2016).

Related City Blueprint Indicators are: 22. Management and action plans; 25. Attractiveness

4.4.3 Social media use

Oslo is trying to increase public awareness using Facebook and Twitter. There are a number of campaigns to inform on measures of how to reduce water use and make the most of this resource:

- H2Oslo which promotes drinking tap water, using reusable water bottles, and informs about water usage, possible water usage reduction, and water challenges in general (Vannkunnskap.no, 2016).

- Garden Watering Campaign – the City of Oslo conducted an awareness campaigns to make people water their gardens more efficiently. They recommend watering at night, cover sun-drenched areas with bark to act as a mulch and use water cans rather than lawn sprinklers. The messages were displayed on cars, public transport and promoted through the media (Ec.europa.eu 2016).
- Water is valuable – Citizens of Oslo can check their water consumption using web-based test. They can also find tips on how to reduce their water consumption. A mobile app was also developed for that purpose. The test was launched during World Water Day 2012 (Vannioslo.no, 2016).
- Facebook campaign – various parties used Facebook to circulate inaccurate stories about an incident and this was only later addressed by the creation of a 'friend' of the municipality who placed corrective messages on Facebook putting the municipality's side of the story

Related City Blueprint Indicators are: 4. Solid waste collected; 20. Drinking water consumption; 23. Public participation

4.4.4 NoDig – Trenchless House Connections to Main Water Lines (NoDigChallenge)

Oslo Kommune Vann- og avløpsetaten (VAV) in cooperation with The National Suppler Development Program, Norsk Vann and Scandinavian Society for Trenchless Technology is seeking a solution of trenchless house connections to main water lines. The time anticipated for trenchless operations is 3 days, which will reduce costs compared to standard methods. VAV indicates that this solution would allow the city to save approximately 40 percent on the cost of such work. In addition to the economic benefit, this solution would have positive social and environmental effects (International.stockholm.se, 2016).

Related City Blueprint Indicators are: 14. Average age sewer; 22. Management and action plans;

5 Conclusion and future work

Firstly the City Blueprint, the Trends and Pressures Framework and the City Amberprint are compared (Figure 5.1).

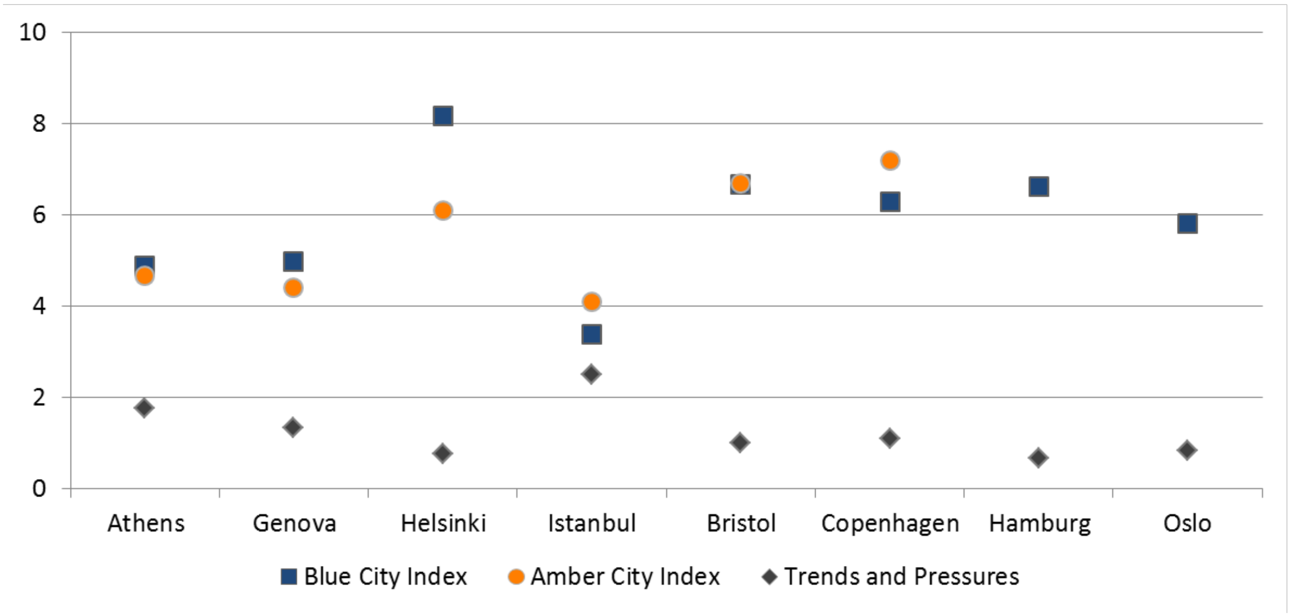

Figure 5.1: Comparison of the Blue City Index, the Amber City Index and the Trends and Pressures Index for all cities. Please note that the Trends and Pressure scores range from 0 (no concern) to 4 points (great concern)

Clearly, there are no considerable trends and pressures in Helsinki and at the same time the Blue City Index score is the highest. The European Green Cities have similar BCI as well as similar TPI with the BCI average at 6.3 and the TPI average at 0.9. Istanbul faces the biggest challenges as the TPI is 2.5 and achieves the BCI is 3.4 and the ACI is 4.1. Results may depend on the size of the city. Bigger cities are facing problems on a bigger scale and require more investment and/or different solutions as some of them may not be scalable. Istanbul has over 14 million citizens, Hamburg has almost 1.8 million citizens and the size of the rest of the cities oscillates around 0.5 million.

Comparison with respect to Trends and Pressures Index for 45 cities is displayed in Figure 5.2. The selection of 8 cities including the case study cities and the European Green cities cover the lowest (Helsinki) and the highest (Istanbul) Trends and Pressures Index.

The averages for each category in the City Blueprint for all the case studies are presented in Figure 5.3. They provide a quick overview of possibilities for potential improvements.

In Figure 5.4 category performance of the City Amberprint for six case study cities: Bristol, Copenhagen, Athens, Genova, Helsinki and Istanbul are presented.

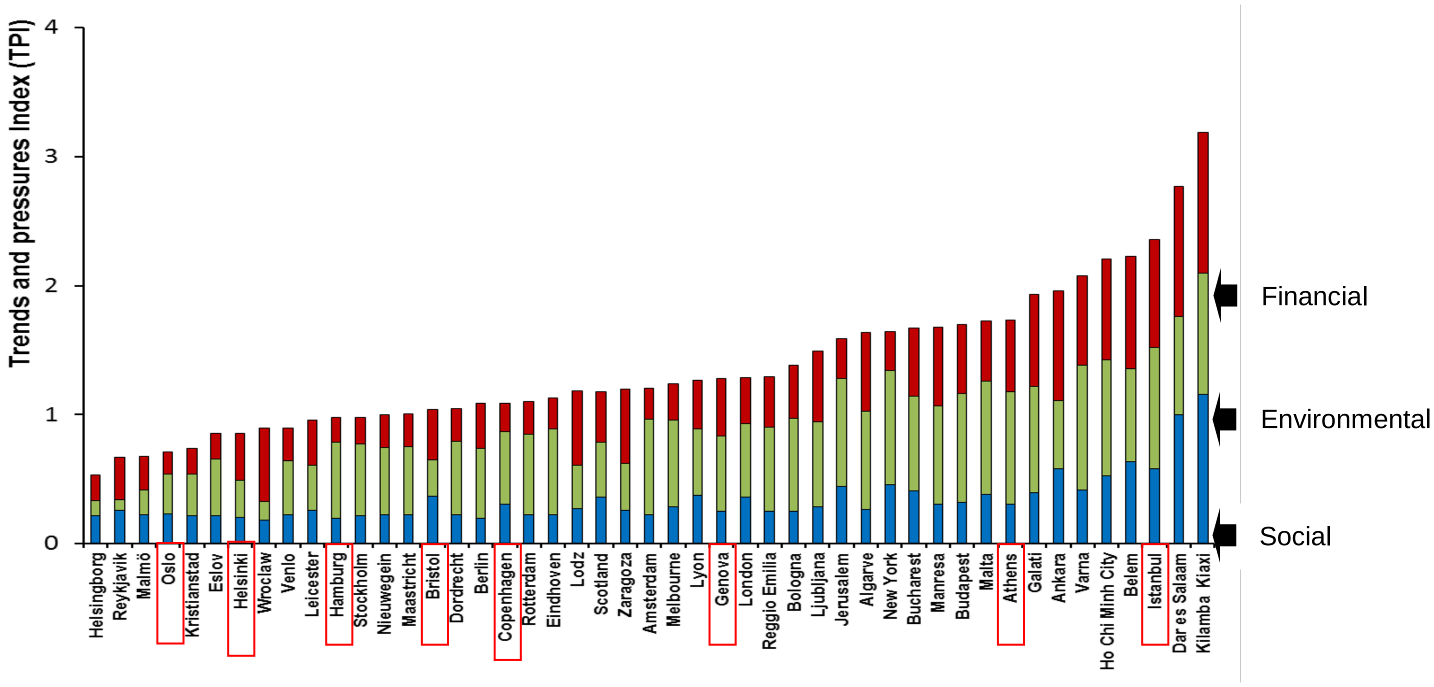

Figure 5.2: Trends and Pressures Index (Koop, S.H.A. and Van Leeuwen, C.J. 2015b)

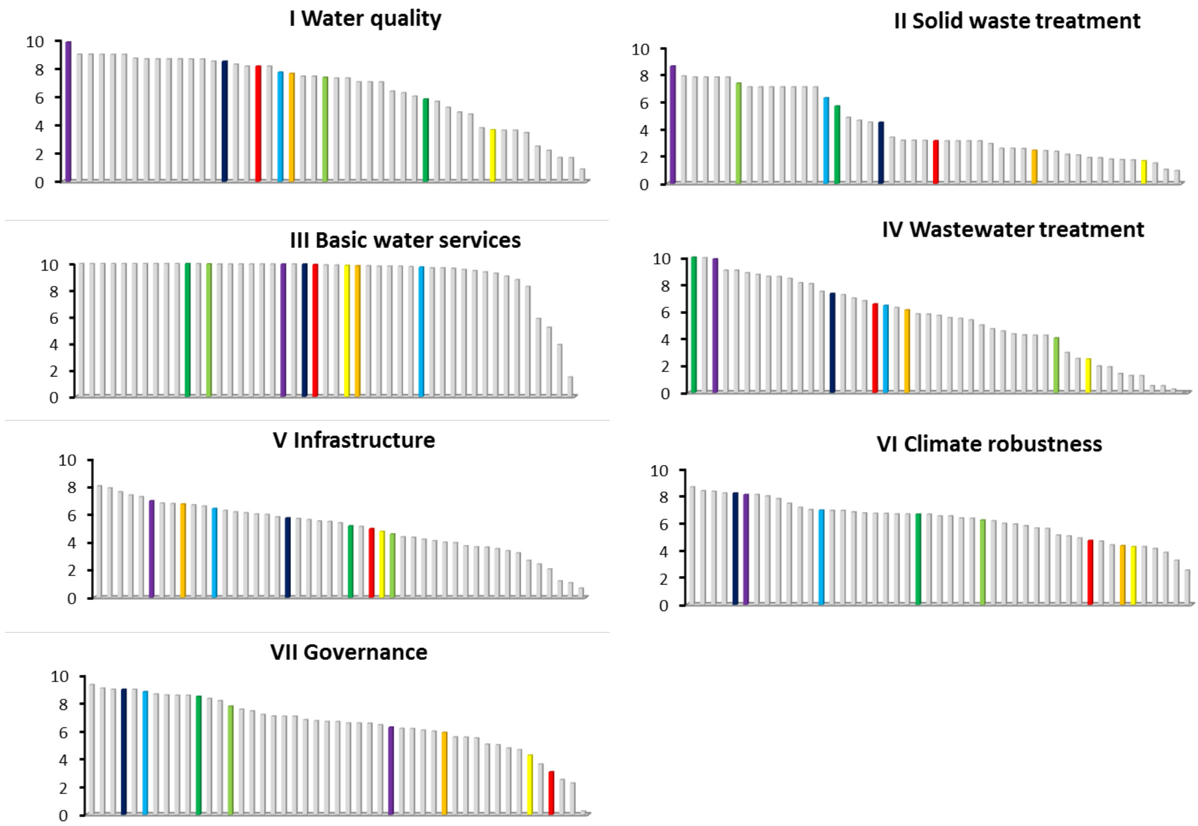

Figure 5.3: Category ranking of the City Blueprints of Bristol (dark green), Copenhagen (light blue), Hamburg (dark blue), Oslo (light green), Athens (orange), Genova (red), Helsinki (purple) and Istanbul (yellow). The arithmetic average of the indicator scores for each of the seven categories are ranked from high to low for each of the 8 cities (Koop, S.H.A. and Van Leeuwen, C.J. 2015b)

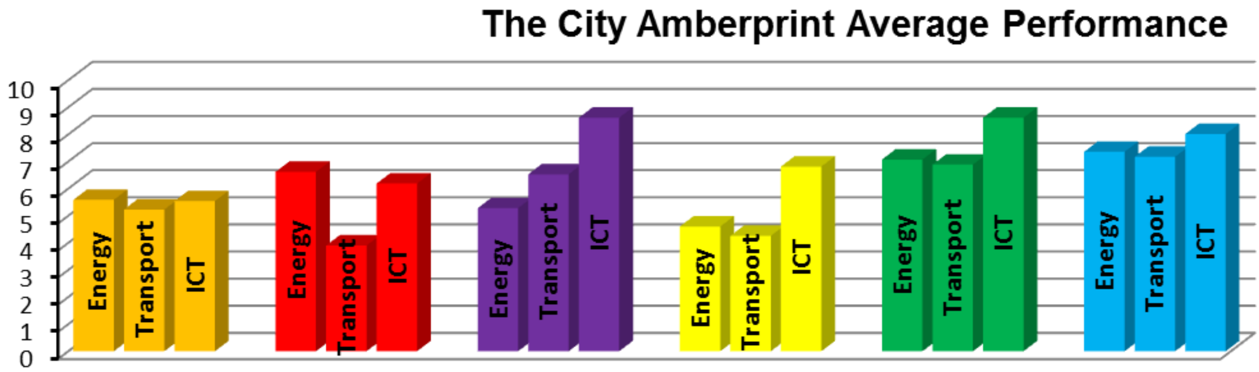

Figure 5.4: Category performance of the City Amberprints of Athens (orange), Genoa (red), Helsinki (purple), Istanbul (yellow), Bristol (dark green) and Copenhagen (light blue). The arithmetic average of the indicator scores for each of the three categories (BlueSCities, 2016)

The objective of this task was to start collecting, sharing and disseminating the best practices in water and waste management. A sample of existing best practices is presented in Chapter 4. The best practices are changing in time and it is a continuous process which requires constant attention.

Another objective of this task was to facilitate start of sharing the best practices. The following approach is proposed. For each City Blueprint indicator with high score relevant best practices from all cities should be available. Cities that are scoring low in the same indicator could be able to access these best practices and consider whether it is possible to transfer them to their specific situation. In this process the Trends and Pressures performance in both cities should be included. Consider for instance Indicator 12. Sewage sludge recycling. In Bristol the score for this indicator is 10. The best practice related to this indicator, Advanced anaerobic digesters is described in section 4.1.2, where waste and sludge from households is recycled via producing bio-gas which in turn is used to generate power, heat houses and fuel public transport buses. The score for this Indicator in Istanbul is 3.5. However, because sludge is obtained from secondary wastewater treatment (Indicator 1 Secondary WWT) the municipality in Istanbul faces a choice whether to invest first in the secondary treatment or improve the sludge recycling by introducing this best practice.

The best practices gathered here together with existing in the consortium background knowledge about technology and governance solutions will help formulate practical guidance document in WP4.

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