BlueSCities

Deliverable Title	**D3.1 Report on the applied methodology**
Deliverable Lead:	De Montfort University
Related Work Package:	WP3: City Case Studies
Related Task:	T3.1: Formulation of the methodology/questionnaire for the analysis of the four cities
Author(s):	Anna Strzelecka, Bogumil Ulanicki
Dissemination Level:	Public
Due Submission Date:	30.09.2015
Actual Submission:	12.11.2015
Project Number	642354
Instrument:	Coordination and Support Action
Start Date of Project:	01.02.2015
Duration:	24 months
Abstract	The key objective was to develop a methodology to assess a city performance from the sustainability point of view and which would include the energy, transport and ICT aspects. The 22 indicators are proposed which measure so called City Amberprint. Overall score of sustainability is expressed as Amber City Index (ACI). The ACI is the geometric mean of the 22 indicators. In order to evaluate numerical values of these indicators it is necessary to complete the questionnaire which is the main outcome of this task.

European Commission

THE FRAMEWORK PROGRAMME FOR RESEARCH AND INNOVATION HORIZON 2020

Project funded by the European Commission as part of the EU Framework Programme for Research and Innovation

Table of Contents

Versioning and Contribution History

D3.1. V0.1 – Anna Strzelecka and Bogumil Ulanicki 02/03/2015

D3.1. V0.2 – Anna Strzelecka and Bogumil Ulanicki 07/08/2015

D3.1. V0.3 – Anna Strzelecka and Bogumil Ulanicki based on input from Mona Arnold, Kees van Leeuwen, Stef Koop and Nicola Bazzurro 13/09/2015

D3.1. V0.4 – Anna Strzelecka and Bogumil Ulanicki based on input from Kees van Leeuwen, Stef Koop and Peter Easton 23/09/2015

D3.1. V0.5 – Anna Strzelecka and Bogumil Ulanicki based on input from Dubrovnik meeting attendees 30/09/2015

D3.1. V0.6 – Anna Strzelecka and Bogumil Ulanicki based on input from Stef Koop, Frederic Clarens 19/10/2015

D3.1. V0.7 – Anna Strzelecka and Bogumil Ulanicki based on input from Kees van Leeuwen, Stef Koop and Nicola Bazzurro 10/11/2015

Executive Summary

The key objective was to develop a methodology to assess a city performance from the sustainability point of view and which would include the energy, transport and ICT aspects. The 22 indicators are proposed (7 for energy, 7 for transport and 8 for ICT) which measure so called City Amberprint. Overall score of sustainability is expressed as Amber City Index (ACI). The ACI is the geometric mean of the 22 indicators for energy, transport and ICT. The methodology is partially based on ideas developed in City Blueprints and existing indicators from literature. In order to evaluate numerical values of these indicators it is necessary to complete the questionnaire which is the main outcome of this task.

1 Introduction

According to World Health Organization the urban population in 2014 accounted for 54% of the total population resulting with almost 4 billion people living in cities, [1]. The United Nations estimates that by 2050 another 2.5 billion people will live in urban areas. Most of the predicted urban growth will take place in developing countries, mainly Africa and Asia. These countries will have to manage numerous challenges resulting from such a rapid growth, i.e. providing housing, expanding and maintaining infrastructures for all five aspects: water, waste, energy, transport and ICT, facilitating education and health care, etc., [2].

City Amberprint is a complement to the City Blueprint and the Trends and Pressures Framework described in D2.2.Application of the Improved City Blueprint Framework in 45 municipalities and regions.

The main goal of City Amberprint is a baseline assessment of the sustainability of energy, transport and ICT in cities. To comply with the City Blueprint, indicators that have a score between 0 (there is a concern) to 10 (no concern) are proposed, [3]. The quantitative indicators were “normalised” on a scale of 0 to 10, where 10 points were assigned to cities that met or exceeded certain criteria on environmental performance. The structure of the City Amberprint Questionnaire is similar to the City Blueprint Questionnaire. Similarly to the City Blueprint the overall score of sustainability is expressed as Amber City Index (ACI). The ACI is the geometric mean of the 22 indicators for energy, transport and ICT. The visual representation of the City Amberprint is a radar chart similar to the one presented in Figure 1.1.

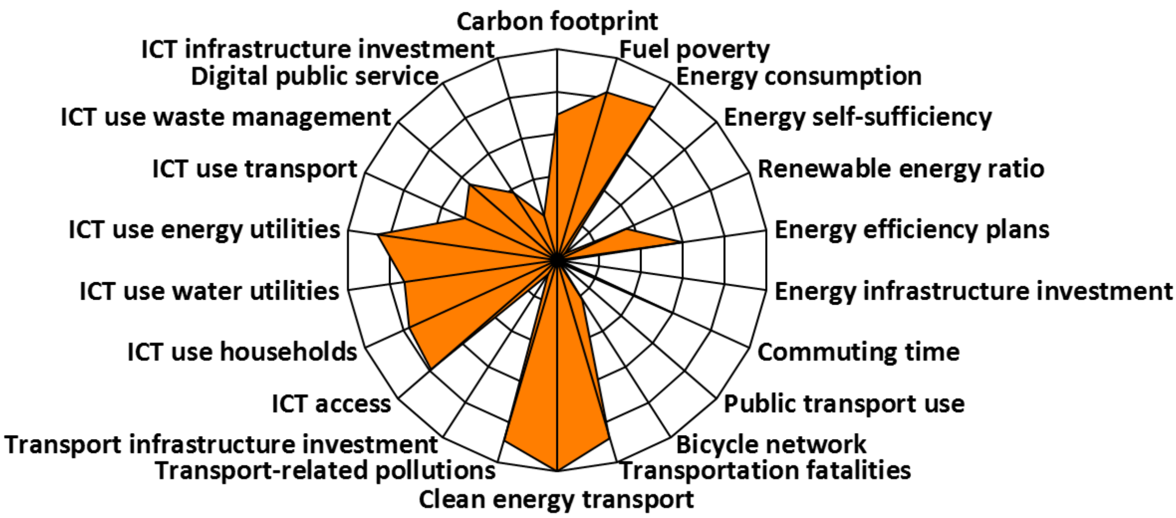

Figure 1.1: City Amberprint of Anycity . The centre of the circle corresponds to 0 and its periphery to 10. The Amber City Index (ACI) for Anycity is 4.3

The indicators in the City Amberprint are introduced to: (i) evaluate current state of the sustainability in the cities, (ii) identify the best practices and share them with other municipalities, (iii) find direct links between the City Amberprint indicators and five aspects of a smart city: water, waste, energy, transport and ICT, (iv) inform citizens and stakeholders about the current situation in the city.

The methodology was based on ideas developed in the City Blueprints and existing indicators from literature, such as Green City Index [4], ISO indicators [5], PLEEC Planning for Energy Efficient Cities project [6], The Digital Economy and Society Index (DESI) [7], and others. The methodology was tested on Leicester in the UK. However, the data used to calculate the indicators needs to be approved by Leicester City Council and cannot be officially disseminated yet.

The document is structured as follows: in section 2 the indicators are explained and direct links between them and the five aspects of a smart city: water, waste, energy, transport and ICT are identified. The document concludes in section 3. The questionnaire is presented in the appendix.

2 Methodology

2.1 Introduction

The 22 indicators have been developed in three categories: energy, transport and ICT. Each of the indicators has a score 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 cities that met or exceeded certain criteria on environmental performance. The overall score of sustainability is expressed as Amber City Index (ACI). The ACI is the geometric mean of the 22 indicators for energy, transport and ICT. The geometric mean is calculated according to the formula:

$$\mathrm{ACI} = \left[\prod_{i=1}^{22} (\mathrm{Indicator}\ i + 1)\right]^{1/22} - 1$$

The indicators are constructed in such a way to represent:

- environmental impact of the city
- quality of life
- risks, for instance interruption of the services provision
- actions of the city to improve all three.

Additionally direct links between the 22 indicators and five aspects of a smart city: water, waste, energy, transport and ICT were identified based on the literature review.

2.2 Energy Indicators

2.2.1 Indicator 1 - CARBON FOOTPRINT (environmental impact)

Carbon Footprint: the total sets of greenhouse gas emissions caused by an organization, event, product or person, [8]. The carbon footprint (CF) per person in the city is compared with the international range. A lower indicator score is given for a larger carbon footprint. It is calculated by comparing the value from the city with the international range. The CF value from the city is standardized with the average of the upper and lower 10% of available data, [9]. A similar indicator can be found in [4].

Indicator 1 - CARBON FOOTPRINT – direct links

Water	Energy is used to pump clean water and wastewater; energy can be generated from wastewater or from clean water (turbines)
Waste	Waste disposal contributes to CO_2 emissions (e.g. landfill sites), reuse and recycling can reduce CO_2 emissions
Energy	
Transport	Transport generates CO_2 (e.g. from combustion engines)
ICT	ICT can improve efficiency of many processes/plants which generate CO_2 (e.g. by more energy efficient operation)

2.2.2 Indicator 2 - FUEL POVERTY (quality of life)

It is very important to establish how many people in a smart city are considered to be fuel poor.

Under the Low Income High Costs definition [10], a household is considered to be fuel poor if:

- they have required fuel costs that are above average (the national median level)
- were they to spend that amount, they would be left with a residual income below the official poverty line.

The indicator presents the proportion of households in the city that are considered to be fuel poor. The lower indicator score is given when the proportion is higher.

Indicator 2 - FUEL POVERTY – direct links

Water	no direct links identified
Waste	can be considered as fuel
Energy	
Transport	no direct links identified
ICT	can alleviate the fuel poverty by efficient use of energy

2.2.3 Indicator 3 - ENERGY CONSUMPTION (environmental impact)

This indicator presents how does total energy consumption (domestic, industrial and commercial, and transport) per capita in the city compares with the international range. A lower indicator score is given where the consumption is greater.

The total energy consumption in the city (kgoe/cap/yr) is placed between the highest 10% and the lowest 10% of international values of energy consumption per capita per year [11].

Energy consumption includes: coal (includes coal consumed in all the following sectors: Heat Generation, Energy Industry use, Industry, Public administration, Commercial, Agriculture, Miscellaneous); manufactured fuels (includes only manufactured solid fuels and not derived gases); Petroleum products (includes petroleum consumed in all the following sectors: Heat Generation, Energy Industry use, Industry, Public administration, Commercial, Agriculture, Miscellaneous); gas; electricity; bioenergy and wastes. A similar indicator can be found in [4].

Indicator 3 - ENERGY CONSUMPTION – direct links

Water	Water usage contributes to energy consumption
Waste	The quantity of waste produced affects the energy consumption of the waste treatment and disposal process
Energy	
Transport	Transport contributes to energy consumption
ICT	ICT can improve efficiency of many processes/plants (e.g. smart building technologies built on ICT systems can make building design, construction and operation more energy efficient)

2.2.4 Indicator 4 - ENERGY SELF-SUFFICIENCY (risk reduction)

Measure of the proportion of a city's demand that could be met through indigenous production including renewable resources, waste, and traditional but generated locally in the city. A lower indicator score is given where self-sufficiency is lower. The indicators shows how resilient city is in case of a sudden loss of connection with the power grid.

Indicator 4 - ENERGY SELF-SUFFICIENCY – direct links

Water	Energy is used to pump clean water and wastewater; energy can be generated from wastewater or from clean water (turbines)
Waste	Some of the energy demand could be obtained from waste incineration. Organic waste and bio-masses can be seen as a renewable source of bio-gas (for instance, when added to sludge in the process of co-digestion)
Energy	
Transport	Hybrid vehicles are capable of producing part of the energy they use for motion
ICT	no direct links identified

2.2.5 Indicator 5 - RENEWABLE ENERGY RATIO (environmental impact)

A measure of proportion of total energy derived from renewable sources, as a share of the city's total energy consumption compared to the international range. A lower indicator is given where the percentage is lower.

The share of a city's total energy consumption derived from renewable sources is calculated as the percentage of total energy derived from renewable sources and placed between the highest 10% and the lowest 10% of international values [12]. Consumption of renewable sources should include geothermal, solar, wind, hydro, tide and wave energy, and combustibles, such as biomass. Similar indicators can be found in [4, 5]

Indicator 5 - RENEWABLE ENERGY RATIO – direct links

Water	no direct links identified
Waste	Some of the energy demand could be obtained from waste (e.g. sludge can be used to produce energy)
Energy	
Transport	no direct links identified
ICT	no direct links identified

2.2.6 Indicator 6 - ENERGY EFFICIENCY PLANS (action plan)

Measure of the application of energy efficiency measures by the range of energy users across the city. A lower indicator score is given where efficiency measures are more limited. This measure is unlikely to already have a value applied. Instead, apply a self assessment based on information from public sources (national/regional/local policy document, reports and websites of actors (e.g. energy companies, cities, provincial or national authorities). It should consider plans, measures and their implementation to improve the efficiency of energy usage

- at household level, e.g. efficient household appliances
- at community level by energy efficient buildings or energy recycling, e.g. heat can be collected in summer, and stored for use in winter
- by encouraging people to change their behaviour.

Similar indicators can be found in [4, 13]

Indicator 6 - ENERGY EFFICIENCY ACTION PLANS – direct links

Water	Water efficient appliances can contribute to efficient energy use
Waste	Some of the energy demand could be obtained from waste (e.g. waste incineration)
Energy	
Transport	Energy efficient means of public and private transportation (bio-gas powered bus and coaches, high efficient car engines, hybrid vehicles, etc.)
ICT	ICT can improve efficiency of many processes/plants (e.g. through running heating or cooling according to each occupant's needs)

2.2.7 Indicator 7 - ENERGY INFRASTRUCTURE INVESTMENT (action plan)

A measure of the investment in the infrastructure for energy distribution compared to the international range. A lower indicator score is given where the investment is lower. The infrastructure investment is an indication of the commitment to regularly invest in the energy infrastructure. Investment can be in:

- a new infrastructure
- maintaining
- and refurbishing the existing one

The investment in the city/region is placed between the highest 10% and the lowest 10% of international values, [14].

Indicator 7 - ENERGY INFRASTRUCTURE INVESTMENT – direct links

Water	Investment in the energy infrastructure can prompt water utilities to carry out the necessary work (e.g. replacing old pipes, or installing new ones)
Waste	no direct links identified
Energy	
Transport	Road works associated with investment in the energy infrastructure may disturb transport
ICT	Investment in the energy infrastructure can prompt ICT companies to carry out the necessary work

2.3 Transport Indicators

2.3.1 Indicator 8 - COMMUTING TIME (quality of life)

A measure of the proportion of time spent on commuting (minutes per day). Includes average time spent in: public transport (bus, coach, train, underground, tram, light railway), car (as driver or passenger), motorcycle, moped, scooter, bicycle, taxi on the way to and from work. A lower indicator score is given where the time spent on commuting is greater.

Commuting time is calculated as average time spent on commuting in one day (in minutes) compared to the international range, [15, 16].

Indicator 8 - COMMUTING TIME – direct links

Water	no direct links identified
Waste	no direct links identified
Energy	Availability of energy can affect the commuting time
Transport	
ICT	ICT can improve efficiency of managing transport in the city reducing commuting time

2.3.2 Indicator 9 - PUBLIC TRANSPORT USE (environmental impact)

Kilometres travelled by public transport and bicycles compared to overall kilometres travel by all means of transport. A lower indicator score is given where the use of public transport and bicycles is higher.

Similar indicator can be found in [4].

Indicator 9 - PUBLIC TRANSPORT USE – direct links

Water	Can be used as infrastructure for transportation
Waste	Can be used as a fuel for public transport
Energy	is required for transportation
Transport	
ICT	ICT can improve efficiency of managing transport in the city

2.3.3 Indicator 10 - BICYCLE NETWORK (environmental impact)

Length of bicycle network per inhabitant compared to the international range. The lower indicator score is given where the length of bicycle network per inhabitant is lower. It includes networks removed from the road, marked and signed only along street and roads, physically separated along streets and roads. This data already exist for some cities. Total length of bicycle network per capita will be compared with Amsterdam, where there is 2.03 metres of bicycle network per capita (and the shortest is 0 metres per capita).

Similar indicator can be found in [4, 6]

Indicator 10 - BICYCLE NETWORK – direct links

Water	good bicycle paths are often along canals
Waste	no direct links identified
Energy	no direct links identified
Transport	
ICT	no direct links identified

2.3.4 Indicator 11 - TRANSPORTATION FATALITIES (quality of life)

A measure of transportation fatalities per year. A lower indicator score is given where the number is greater. Transportation fatalities per 100 000 population is calculated as the number of fatalities related to transportation of any kind within the city borders, divided by one 10 000th of the city's total population. The result is expressed as the number of transportation fatalities per 100 000 population and compared to the international range, [17]. The city should include in this indicator deaths due to any transportation-related proximate causes in any mode of travel (automobile, public transport, walking, bicycling, etc.). The city should count any death directly related to a transportation incident within city limits, even if death does not occur at the site of the incident, but is directly attributable to the accident. A similar indicator can be found in [5].

Indicator 11 - TRANSPORTATION FATALITIES – direct links

Water	no direct links identified
Waste	no direct links identified
Energy	no direct links identified
Transport	
ICT	ICT can improve efficiency of managing transport in the city

2.3.5 Indicator 12 - CLEAN ENERGY TRANSPORT (action plan)

Clean energy transport and clean energy sharing transport. A lower indicator score is given where efficiency measures are more limited. This measure is unlikely to already have a value applied. Instead, apply a self assessment based on information from public sources (national/regional/local policy document, reports and websites of actors (e.g. transport companies, cities, provincial or national authorities). It should consider plans, measures and their implementation to improve the transport efficiency by e.g.

- efficient public transport (electric train, subway/metro, tram, cable railway)
- efficient private transport (electric taxis or cars, electric scooter, bicycling)
- and encouragements to use public transport.

Similar indicators can be found in [4, 13].

Indicator 12 - CLEAN ENERGY TRANSPORT – direct links

Water	Clean transportation reduces water pollution and purification costs
Waste	no direct links identified
Energy	Clean energy means of transport reduce the exploitation of other energy sources
Transport	
ICT	ICT can help to plan to achieve higher level of efficiency of transport

2.3.6 Indicator 13 - TRANSPORT-RELATED POLLUTIONS (environmental impact)

Air pollutant emissions (Carbon monoxide (CO), Nitrogen oxides (NO_x), Particulates (PM_{10}) - airbourne particulate matter with aerodynamic diameter less than 10 micrometres, Particulates ($PM_{2.5}$) - airbourne particulate matter with aerodynamic diameter less than 2.5 micrometres, Benzene, 1,3-butadiene, Lead (Pb), Sulphur oxides (SO_x)) from transport compared with the international range [18]. A lower indicator score is given where the pollutant emissions are greater. A similar indicator can be found in [4].

Indicator 13 - TRANSPORT-RELATED POLLUTIONS – direct links

Water	Pollutants from road surfaces contaminate drainage water
Waste	no direct links identified
Energy	no direct links identified
Transport	
ICT	ICT can improve efficiency of managing transport in the city

2.3.7 Indicator 14 - TRANSPORT INFRASTRUCTURE INVESTMENT (action plan)

A measure of the investment in the transport infrastructure compared to the international range. A lower indicator score is given where the investment is lower. The infrastructure investment is an indication of the commitment to regularly invest in the transport infrastructure. Investment can be in:

- a new infrastructure
- maintaining
- and refurbishing the existing one.

The investment in the city/region is placed between the highest 10% and the lowest 10% of international values [19].

Indicator 14 - TRANSPORT INFRASTRUCTURE INVESTMENT – direct links

Water	Investment in transport infrastructure, e.g. by refurbishing roads, may prompt water utilities to carry out necessary works
Waste	no direct links identified
Energy	Investment in transport infrastructure may prompt energy utilities to carry out necessary works
Transport	
ICT	Investment in transport infrastructure may prompt ICT companies to carry out necessary works

2.4 ICT Indicators

2.4.1 Indicator 15 - ICT ACCESS (quality of life)

The ICT access is a measure of access to information and communication technology (ICT) in the city. It includes:

- Mobile-cellular telephone subscriptions per 100 inhabitants.
- International Internet bandwidth (bit/s) per Internet user.
- Proportion of households with a computer.
- Proportion of households with Internet access.

A lower indicator score is given where the ICT access is lower. This indicator is based on indicators in [20].

Indicator 15 - ICT ACCESS – direct links

Water	People have more tools to get informed about water topics. It increases awareness
Waste	People have more tools to get informed about waste topics. It increases awareness
Energy	People have more tools to get informed about energy topics. It increases awareness
Transport	Access to information about public transport, traffic, available routes
ICT	

2.4.2 Indicator 16 - ICT USE HOUSEHOLDS (quality of life)

The ICT use is a measure of use of information and communication technology (ICT) in the city. It includes:

- Proportion of individuals using the Internet.
- Fixed (wired)-broadband subscriptions per 100 inhabitants.
- Wireless-broadband subscriptions per 100 inhabitants.

A lower indicator score is given where the ICT use is lower. This indicator is based on indicators in [20].

Indicator 16 - ICT USE HOUSEHOLDS – direct links

Water	People have more tools to get informed about water topics. It increases awareness
Waste	People have more tools to get informed about waste topics. It increases awareness
Energy	People have more tools to get informed about energy topics. It increases awareness
Transport	People have more tools to get informed about transport topics. It increases awareness
ICT	

2.4.3 Indicator 17 - ICT USE WATER UTILITIES (environmental impact, quality of life, risk reduction)

A measure of ICT implementation at the city utility level. It includes:

- Operation, e.g. SCADA system, energy management.
- Maintenance, e.g. asset management data base and GIS.
- Planning and design, e.g. optimisation, GIS interface.
- Customer service, e.g. smart metering.

A lower indicator score is given where there are less ICT tools implemented.

Indicator 17 - ICT USE WATER UTILITIES – direct links

Water	
Waste	no direct links identified
Energy	The ICT use by water utilities can help them in achieving an optimized management with potential saving in energy consumption
Transport	no direct links identified
ICT	

2.4.4 Indicator 18 - ICT USE ENERGY UTILITIES (environmental impact, quality of life, risk reduction)

A measure of ICT implementation at the city utility level. It includes:

- Operation, e.g. SCADA system, energy management.
- Maintenance, e.g. asset management data base and GIS.
- Planning and design, e.g. optimisation, GIS interface.
- Customer service, e.g. smart metering.

A lower indicator score is given where there are less ICT tools implemented.

Indicator 18 - ICT USE ENERGY UTILITIES – direct links

Water	no direct links identified
Waste	no direct links identified
Energy	
Transport	no direct links identified
ICT	

2.4.5 Indicator 19 - ICT USE TRANSPORT (environmental impact, quality of life, risk reduction)

A measure of ICT implementation at the city utility level. It includes:

- Operation, e.g. coverage of installation of road sensing terminals and traffic control in the city.

- Maintenance, e.g. is there ICT system for planning the road maintenance and public transport vehicles?
- Planning and design, e.g. is there ICT system for planning transport infrastructure expansion and improvement?
- Customer service, e.g. mobile bus tickets, online feedback forms.

A lower indicator score is given where there are less ICT tools implemented. Some of the aspects can be found in [13].

Indicator 19 - ICT USE TRANSPORT – direct links

Water	no direct links identified
Waste	no direct links identified
Energy	The use of ICT in transport management can help reducing travel times and energy consumption
Transport	
ICT	

2.4.6 Indicator 20 - ICT USE WASTE MANAGEMENT (environmental impact, quality of life, risk reduction)

A measure of ICT implementation at the city utility level. A lower indicator score is given where there are less ICT tools implemented.

- Operation, e.g. ICT system for logistics of waste collection.
- Maintenance, e.g. is there ICT system for the pro-active maintenance of waste collection infrastructure?
- Planning and design, e.g. is there ICT system for planning future enhancements and improvement of waste infrastructure?
- Customer service, e.g. smart labelling of waste bags, online feedback forms, citizen engagement.

Indicator 20 - ICT USE WASTE MANAGEMENT – direct links

Water	no direct links identified
Waste	
Energy	no direct links identified
Transport	no direct links identified
ICT	

2.4.7 Indicator 21 - DIGITAL PUBLIC SERVICE (quality of life)

A measure of ICT implementation within public administration (percentage of Internet users that have engaged with the public administration and exchanged filled forms online) and health system. It includes:

- Proportion of eGovernment Users. Proportion of individuals sending filled forms over the internet to public authorities, or contacting public authorities by e-mail or website, or obtaining information from public authorities over the internet.
- Medical Data Exchange. Proportion of general practitioners using electronic networks to exchange medical data with other health care providers and professionals and to transfer prescriptions to pharmacists.

A lower indicator score is given where there are less ICT tools implemented. The indicator was based on work by [7].

Indicator 21 - DIGITAL PUBLIC SERVICE – direct links

Water	no direct links identified
Waste	no direct links identified
Energy	no direct links identified
Transport	Digital public services imply a reduced number of visits of customers and citizens to public offices, with benefits in terms of traffic congestion
ICT	

2.4.8 Indicator 22 - ICT INFRASTRUCTURE INVESTMENT (action plan)

A measure of the investment in the ICT infrastructure compared to the international range. A lower indicator score is given where the investment is lower. The infrastructure investment is an indication of the commitment to regularly invest in the ICT infrastructure. Investment can be in:

- a new infrastructure
- maintaining
- and refurbishing the existing one.

The investment in the city/region is placed between the highest 10% and the lowest 10% of international values [21].

Indicator 22 - ICT INFRASTRUCTURE INVESTMENT – direct links

Water	investment in ICT infrastructure, e.g. by refurbishing roads, may prompt water utilities to carry out necessary works
Waste	no direct links identified
Energy	investment in ICT infrastructure, e.g. by refurbishing roads, may prompt energy utilities to carry out necessary works
Transport	road works associated with investment in the ICT infrastructure may disturb transport
ICT	

3 Conclusion

The City Amberprint was developed to assess the sustainability of energy, transport and ICT in cities. The City Amberprint questionnaire was developed for that purpose. It contains 22 indicators: 7 for energy, 7 for transport and 8 for ICT. The overall sustainability of the three aspects is expressed as Amber City Index (ACI). The ACI is the geometric mean of the 22 indicators.

The developed methodology was tested on Leicester in the UK. Majority of the data is publicly available, some data needs to be obtained directly from City Council. All information requires final approval from the City Council. The City Amberprint questionnaire will be now executed in the four smart cities: Copenhagen, Bristol, Oslo and Hamburg as well as four case study cities: Genoa, Athens, Helsinki and Istanbul.

APPENDIX A Questionnaire

Questions of the City Amberprint

Introduction

City Amberprint is a complement to the City Blueprint and the Trends and Pressures Framework.
The main goal of the City Amberprint is a baseline assessment of the sustainability of Energy, Transport and ICT in cities. To comply with City Blueprint, indicators that have a score between 0 (there is a concern) to 10 (no concern) are proposed. The quantitative indicators were "normalise" on a scale of 0 to 10, where 10 points were assigned to cities that met or exceeded certain criteria on environmental performance.

The structure is similar to the City Blueprint.

Project funded by the European Commission as part of the EU Framework Programme for Research and Innovation

A.1 Energy Indicators

A.1.1 Indicator 1 - CARBON FOOTPRINT

Principal: How does your carbon footprint (CF) per person compare with the international range? A lower indicator score is given for a larger carbon footprint.

How to calculate:

The CF value for your city is standardized with the average of the upper and lower 10% of available data.

Average minimum CF in 2012 was 0.237 (tonnes CO_2/capita/year).

Average maximum CF in 2012 was 16.464 (tonnes CO_2/capita/year).

Where the CF/capita value for your city is **X**, the indicator is calculated as follows:

Indicator 1 $= 10 \times \frac{\mathbf{16.464 - X}}{\mathbf{16.464 - 0.237}}$

Definition of Carbon Footprint: the total sets of greenhouse gas emissions caused by an organization, event, product or person.

Example. For Anycity the CF value is 5.161 tonnes/cap/year (2013). Therefore:

Indicator 1 = $10 \times \frac{16.464 - 5.161}{16.464 - 0.237} = 6.9$

Where to get the data:

For the UK:

`https://www.gov.uk/government/statistics/uk-local-authority-and-regional-carbon-dioxi`

`https://data.oecd.org/air/air-and-ghg-emissions.htm`

Indicator 1 evaluation

Description	**Units**	**Value**	**Code in formula**
Carbon Footprint/capita	tCO_2/cap/yr		**X**
Formula		$10 \times \frac{\mathbf{16.464 - X}}{\mathbf{16.464 - 0.237}}$	
Result			

Indicator 1 - CARBON FOOTPRINT – direct links

Water	Energy is used to pump clean water and wastewater; energy can be generated from wastewater or from clean water (turbines)
Waste	Waste disposal contributes to CO_2 emissions (e.g. landfill sites), reuse and recycling can reduce CO_2 emissions
Energy	
Transport	Transport generates CO_2 (e.g. from combustion engines)
ICT	ICT can improve efficiency of many processes/plants which generate CO_2 (e.g. by more energy efficient operation)

A.1.2 Indicator 2 - FUEL POVERTY

Principal: What is the proportion of households in the city that are considered to be fuel poor? The lower indicator score is given when the proportion is higher.

How to calculate:

Under the Low Income High Costs definition, a household is considered to be fuel poor if:

- they have required fuel costs that are above average (the national median level)
- were they to spend that amount, they would be left with a residual income below the official poverty line.

The indicator is calculated as the percentage of households in the city that is considered to be fuel poor **X** divided by 10.

Therefore:

$\mathbf{Indicator\ 2 = (100 - X)/10}$

Example. For Anycity the percentage of households which is considered to be fuel poor is 16.6% (in 2013). Therefore:

$\text{Indicator 2} = (100 - 16.6)/10 = 8.3$

Where to get the data:

Data for cities needs to be researched locally.

For the UK:

https://www.gov.uk/government/statistics/2013-sub-regional-fuel-poverty-data-low-inc

Indicator 2 evaluation

Description	Units	Value	Code in formula
% of fuel poor households	%		**X**
Formula		$\mathbf{(100 - X)/10}$	
Result			

Indicator 2 - FUEL POVERTY – direct links

Water	no direct links identified
Waste	can be considered as fuel
Energy	
Transport	no direct links identified
ICT	can alleviate the fuel poverty by efficient use of energy

A.1.3 Indicator 3 - ENERGY CONSUMPTION

Principal: This indicator presents how does total energy consumption (domestic, industrial and commercial, and transport) per capita in the city compares with the international range. A lower indicator score is given where the consumption is greater.

How to calculate:

The total energy consumption in the city (kgoe/cap/yr) is placed between the highest and the lowest energy consumption per capita per year.

Energy consumption includes: coal (includes coal consumed in all the following sectors: Heat Generation, Energy Industry use, Industry, Public administration, Commercial, Agriculture, Miscellaneous); manufactured fuels (includes only manufactured solid fuels and not derived gases); Petroleum products (includes petroleum consumed in all the following sectors: Heat Generation, Energy Industry use, Industry, Public administration, Commercial, Agriculture, Miscellaneous); gas; electricity; bioenergy & wastes.

The lowest average energy consumption per capita is: 893.15 kgoe/cap/yr (in 2012).

The highest average energy consumption per capita is: 5419.0 kgoe/cap/yr (in 2012).

The indicator is calculated as follows (where **X** is the total energy consumption for city that is under consideration):

$$\mathbf{Indicator\ 3 = 10 \times \frac{5419 - X}{5419 - 893.15}}$$

Example. For Anycity the total energy consumption was 1540.9 kgoe/cap/yr (in 2012). Therefore:

$$\text{Indicator } 3 = 10 \times \frac{5419 - 1540.9}{5419 - 893.15} = 8.6$$

Where to get the data:

`http://ec.europa.eu/eurostat/tgm/table.do?tab=table&init=1&language=en&pcode=ten00095&plugin=1`

`https://www.gov.uk/government/statistical-data-sets/total-final-energy-consumption-at`

For the cities data needs to be researched locally.

Indicator 3 evaluation

Description	**Units**	**Value**	**Code in formula**
Energy consumption	kgoe/cap/yr		**X**
Formula		$\mathbf{10 \times \frac{5419 - X}{5419 - 893.15}}$	
Result			

Indicator 3 - ENERGY CONSUMPTION – direct links

Water	Water usage contributes to energy consumption
Waste	The quantity of waste produced affects the energy consumption of the waste treatment and disposal process
Energy	
Transport	Transport contributes to energy consumption
ICT	ICT can improve efficiency of many processes/plants (e.g. smart building technologies built on ICT systems can make building design, construction and operation more energy efficient)

A.1.4 Indicator 4 - ENERGY SELF-SUFFICIENCY

Principal: Measure of the proportion of a city's demand that could be met through indigenous production including renewable resources, waste, and traditional but generated locally in the city. A lower indicator score is given where self-sufficiency is lower.

How to calculate:

A city is energy self-sufficient if it is able to produce energy locally, e.g. from renewable sources, waste, or using fossil fuels. It shows how resilient city is in case of a sudden loss of connection with the power grid. The indicator is calculated as the amount of energy generated locally **X** to the total energy consumption in the city **Y**.

$\mathbf{Indicator\ 4 = 100 \times X/Y}$

Example. For Anycity the total energy consumption was 1540.9 kgoe/cap/yr (in 2012). The amount of energy generated locally was 99 kgoe/cap/yr (in 2012) Therefore:

$\text{Indicator } 4 = 10 \times 99/1540.9 = 0.64$

Where to get the data:

https://www.gov.uk/government/statistics/energy-trends-december-2014

Indicator 4 evaluation

Description	Units	Value	Code in formula
The amount of energy generated locally	–		
Total energy consumption in the city	–		
Formula		$\mathbf{10 \times X/Y}$	
Result			

Indicator 4 - ENERGY SELF-SUFFICIENCY – direct links

Water	Energy is used to pump clean water and wastewater; energy can be generated from wastewater or from clean water (turbines)
Waste	Some of the energy demand could be obtained from waste incineration. Organic waste and bio-masses can be seen as a renewable source of bio-gas (for instance, when added to sludge in the process of co-digestion)
Energy	
Transport	Hybrid vehicles are capable of producing part of the energy they use for motion
ICT	no direct links identified

A.1.5 Indicator 5 - RENEWABLE ENERGY RATIO

Principal: A measure of proportion of total energy derived from renewable sources in the city, as a share of the city's total energy consumption compared to the international range. A lower indicator is given where the percentage is lower.

How to calculate:

The share of a city's total energy consumption derived from renewable sources is calculated as the percentage of total energy derived from renewable sources **X** and compared to the international range. Consumption of renewable sources should include geothermal, solar, wind, hydro, tide and wave energy, and combustibles, such as biomass.

The lowest average percentage of energy derived from renewable sources is: 1.15% (in 2012).

The highest average percentage of energy derived from renewable sources is: 98.8% (in 2012).

The indicator is calculated as follows (where **X** is the percentage of energy derived from renewable sources):

$$\mathbf{Indicator\ 5 = 10 \times \frac{X - 1.15}{98.8 - 1.15}}$$

Example. For the UK the percentage of total energy derived from renewable sources was 13.9% in 2013. Therefore:

$$\text{Indicator } 5 = 10 \times \frac{13.9 - 1.15}{98.8 - 1.15} = 1.31$$

Where to get the data:

`http://www.eia.gov/beta/international/`

`http://ec.europa.eu/eurostat/web/energy/data/main-tables`

Indicator 5 evaluation

Description	Units	Value	Code in formula
Energy derived from renewable sources as % of total consumption	%		**X**
Formula		$\mathbf{10 \times \frac{X - 1.15}{98.8 - 1.15}}$	
Result			

Indicator 5 - RENEWABLE ENERGY RATIO – direct links

Water	no direct links identified
Waste	Some of the energy demand could be obtained from waste (e.g. sludge can be used to produce energy)
Energy	
Transport	no direct links identified
ICT	no direct links identified

A.1.6 Indicator 6 - ENERGY EFFICIENCY PLANS

Principal: Measure of the application of energy efficiency measures by the range of energy users across the city. A lower indicator score is given where efficiency measures are more limited.

How to calculate:

This measure is unlikely to already have a value applied. Instead, apply a self assessment based on information from public sources (national/regional/local policy document, reports and websites of actors (e.g. energy companies, cities, provincial or national authorities). It should consider plans, measures and their implementation to improve the efficiency of energy usage

- at household level, e.g. efficient household appliances,
- at community level by energy efficient buildings or energy recycling, e.g. heat can be collected in summer, and stored to use it in winter,
- by encouraging people to change their behaviour.

The following guidance is proposed to make self-assessment score for Indicator 6.

Indicator score	Assessment
0	no information is available on this subject
1	limited information is available in a national document
2	limited information is available in national and local documents
3	the topic is addressed in a chapter in a national document
4	the topic is addressed in a chapter at the national and local level
5	a local policy plan is provided in a publicly available document
6	as 5 and the topic is also addressed at the local website
7	plans are implemented and clearly communicated to the public
8	as 7 plus subsidies are made available to implement the plans
9	as 8 plus annual reports are provided on the progress of the implementation and/or any other activity indicating that this is a very high priority implemented at the level of the local community
10	as 9 and the activity is in place for = 3 years

Example. In Anycity plans for energy conservation are clearly communicated to public via website. There is a scheme to install smart meters in the houses by 2020. Therefore Anycity is given a score of 6.

Where to get the data:

Data needs to be researched locally.

Indicator 6 evaluation

Description	**Value**
Energy efficiency	

Indicator 6 - ENERGY EFFICIENCY ACTION PLANS – direct links

Water	Water efficient appliances can contribute to efficient energy use
Waste	Some of the energy demand could be obtained from waste (e.g. waste incineration)
Energy	
Transport	Energy efficient means of public and private transportation (bio-gas powered bus and coaches, high efficient car engines, hybrid vehicles, etc.)
ICT	ICT can improve efficiency of many processes/plants (e.g. through running heating or cooling according to each occupant's needs)

A.1.7 Indicator 7 - ENERGY INFRASTRUCTURE INVESTMENT

Principal: A measure of the investment in the infrastructure for energy distribution compared to the international range. A lower indicator score is given where the investment is lower.

How to calculate:

The infrastructure investment is an indication of the commitment to regularly invest in the energy infrastructure. Investment can be in:

- a new infrastructure
- maintaining
- and refurbishing the existing one.

The investment in the city/region by capita, **X** is calculated as the investment in the city/region **A** in a year (values of the investment over the last 5 years should be taken and average value per year used) divided by local population of the city/region **B**:

$$\mathbf{X = A/B}$$

Subsequently, the investment in the city/region per capita **X** is divided by GDP per capita in the country **Y**.

The average lowest percentage of investment is 0.06%.

The average highest percentage of investment is 2.29%.

Therefore, the indicator is calculated as follows:

$$\mathbf{Indicator\ 7 = \frac{100 \times X/Y - 0.06}{2.29 - 0.06} \times 10}$$

Example: In Anycity £657 million was invested in the energy infrastructure (in the last 5 years; on average per year it is £131.4 million). Population in the area is 4.533 million. Therefore the investment per capita **X** is:

$$X = 131.4/4.533 = 28.99[£/\mathrm{cap}]$$

GDP per capita in the UK is £30074.59 [£/cap]. Therefore:

$$\mathrm{Indicator\ 7} = \frac{100 \times 28.99/30074.59 - 0.06}{2.29 - 0.06} \times 10 = 0.17$$

Where to get the data:

Data for cities needs to be researched locally

Data for countries:

`http://data.worldbank.org/indicator/IE.PPI.ENGY.CD`

Indicator 7 evaluation

Description	Units	Value	Code in formula
Investment in the energy infrastructure per capita (in the city/region)	£(€)/cap		X
GDP per capita (in the country)	£(€)/cap		Y
Formula		$\frac{100 \times X/Y - 0.06}{2.29 - 0.06} \times 10$	
Result			

Indicator 7 - ENERGY INFRASTRUCTURE INVESTMENT – direct links

Water	Investment in the energy infrastructure can prompt water utilities to carry out the necessary work (e.g. replacing old pipes, or installing new ones)
Waste	no direct links identified
Energy	
Transport	Road works associated with investment in the energy infrastructure may disturb transport
ICT	Investment in the energy infrastructure can prompt ICT companies to carry out the necessary work

A.2 Transport Indicators

A.2.1 Indicator 8 - COMMUTING TIME

Principal: A measure of the proportion of time spent on commuting (minutes per day). Includes average time spent in: public transport (bus, coach, train, underground, tram, light railway), car (as driver or passenger), motorcycle, moped, scooter, bicycle, taxi on the way to and from work. A lower indicator score is given where the time spent on commuting is greater.

How to calculate: Commuting time is calculated as average time spent on commuting in one day (in minutes) compared to the international range.

The average minimum time spent on commuting is 10.8 min/day.

The average maximum time spent on commuting is 74.2 min/day.

The indicator is calculated as follows (where **X** is the average time spent on commuting in the city (or region)):

$$\mathbf{Indicator\ 8 = 10 \times \frac{74.2 - X}{74.2 - 10.8}}$$

Example. For Anycity an average time spent on commuting each day is 48.75 minutes (in 2013). Therefore:

$$\text{Indicator } 8 = 10 \times \frac{74.2 - 48.75}{74.2 - 10.8} = 6$$

Where to get the data:

`https://www.tuc.org.uk/`

`http://ec.europa.eu/eurostat/web/products-datasets/-/lfst_r_lfe2ecomm`

`http://www.nationmaster.com/country-info/stats/Transport/Commute/Time-spent`

Data for the cities needs to be researched locally.

Indicator 8 evaluation

Description	**Units**	**Value**	**Code in formula**
Average time spent on commuting	min/day		**X**
Formula		$\mathbf{10 \times \frac{74.2 - X}{74.2 - 10.8}}$	
Result			

Indicator 8 - COMMUTING TIME – direct links

Water	no direct links identified
Waste	no direct links identified
Energy	Availability of energy can affect the commuting time
Transport	
ICT	ICT can improve efficiency of managing transport in the city reducing commuting time

A.2.2 Indicator 9 - PUBLIC TRANSPORT USE

Principal: Kilometres travelled by public transport and bicycles compared to overall kilometres travel by all means of transport. A lower indicator score is given where the use of public transport and bicycles is higher.

How to calculate:

Average kilometres travelled by public transport and bicycles **X** divided by overall kilometres travelled by all means of transport *Y*.

$\mathbf{Indicator\ 9 = 10 \times (X/Y)}$

Example. In Anycity in 2013 overall traffic was 399,844 (thousand vehicle miles) compared to 2,816 (cyclists, pedestrians) and 4,776 public transport (thousand vehicle miles). Therefore:

$\text{Indicator } 9 = 10 \times (7,592/399,844) = 0.18$

Where to get the data:

Data needs to be researched locally.

Indicator 9 evaluation

Description	**Units**	**Value**	**Code in formula**
Km travelled by public transport & cycling	km		**X**
Km travelled by all means of transport	km		**Y**
Formula		$\mathbf{10 \times (X/Y)}$	
Result			

Indicator 9 - PUBLIC TRANSPORT USE – direct links

Water	Can be used as infrastructure for transportation
Waste	Can be used as a fuel for public transport
Energy	is required for transportation
Transport	
ICT	ICT can improve efficiency of managing transport in the city

A.2.3 Indicator 10 - BICYCLE NETWORK

Principal: Length of bicycle network per inhabitant compared to the international range. The lower indicator score is given where the length of bicycle network per inhabitant is lower.

How to calculate:

It includes networks removed from the road, marked and signed only along street and roads, physically separated along streets and roads.

Total length of bicycle network in meters **A** divided by number of inhabitants **B**.

$\mathbf{X = A/B}$

This data already exist for some cities. Total length of bicycle network per capita will be compared with Amsterdam, where there is 2.03 metres of bicycle network per capita (and the shortest is 0 metres per capita). Therefore:

$\mathbf{Indicator\ 10 = 10 \times (X/2.03)}$

Example. Length of designated cycle routes in metres per inhabitant in Anycity in 2013 was 0.44. Therefore:

$\text{Indicator } 10 = 10 \times (0.44/2.03) = 2.2$

Where to get the data:

Data needs to be researched locally.

Indicator 10 evaluation

Description	**Units**	**Value**	**Code in formula**
Length of designated cycle routes	m		**A**
Number of inhabitants	No.		**B**
Total length of bicycle network in meters $\mathbf{X = A/B}$	m/cap		**X**
Formula		$\mathbf{10 \times (X/2.03)}$	
Result			

Indicator 10 - BICYCLE NETWORK – direct links

Water	good bicycle paths are often along canals
Waste	no direct links identified
Energy	no direct links identified
Transport	
ICT	no direct links identified

A.2.4 Indicator 11 - TRANSPORTATION FATALITIES

Principal: A measure of transportation fatalities per year. A lower indicator score is given where the number is greater.

How to calculate:

Transportation fatalities per 100 000 population is calculated as the number of fatalities related to transportation of any kind within the city borders **X**, divided by 100,000 of the city's total population **Y**. The result is expressed as the number of transportation fatalities per 100 000 population and compared to the international range. The city shall include in this indicator deaths due to any transportation-related proximate causes in any mode of travel (automobile, public transport, walking, bicycling, etc.). The city shall count any death directly related to a transportation incident within city limits, even if death does not occur at the site of the incident, but is directly attributable to the accident.

The lowest average transport fatalities per 100 000 population is 3.6 (in 2013).

The highest average transport fatalities per 100 000 population is 33.4 (in 2013).

$$\mathbf{Indicator\ 11} = \mathbf{10} \times \frac{\mathbf{33.4 - X/Y}}{\mathbf{33.4 - 3.6}}$$

Example. In Anycity in 2013 there were 24 killed in traffic accidents. The population of Anycity is 329,839. Therefore:

$$\text{Indicator } 11 = 10 \times \frac{33.4 - (24/329,839) * 100000}{33.4 - 3.6} = 8.8$$

Where to get the data:

Data needs to be researched locally.

Global Status Report on Road Safety 2013: supporting a decade of action. WHO

Indicator 11 evaluation

Description	**Units**	**Value**	**Code in formula**
Number of transportation fatalities	–		**X**
Number of inhabitants	–		**Y**
Formula		$\mathbf{10} \times \frac{\mathbf{33.4 - X/Y}}{\mathbf{33.4 - 3.6}}$	
Result			

Indicator 11 - TRANSPORTATION FATALITIES – direct links

Water	no direct links identified
Waste	no direct links identified
Energy	no direct links identified
Transport	
ICT	ICT can improve efficiency of managing transport in the city

A.2.5 Indicator 12 - CLEAN ENERGY TRANSPORT

Principal: Clean energy transport and clean energy sharing transport. A lower indicator score is given where efficiency measures are more limited.

How to calculate:

This measure is unlikely to already have a value applied. Instead, apply a self assessment based on information from public sources (national/regional/local policy document, reports and websites of actors (e.g. transport companies, cities, provincial or national authorities). It should consider plans, measures and their implementation to improve the transport efficiency by e.g.

- efficient public transport (electric train, subway/metro, tram, cable railway)
- efficient private transport (electric taxis or cars, electric scooter, bicycling)
- and encouragements to use public transport.

The following guidance is proposed to make self-assessment score for Indicator 12.

Indicator score	**Assessment**
0	no information is available on this subject
1	limited information is available in a national document
2	limited information is available in national and local documents
3	the topic is addressed in a chapter in a national document
4	the topic is addressed in a chapter at the national and local level
5	a local policy plan is provided in a publicly available document
6	as 5 and the topic is also addressed at the local website
7	plans are implemented and clearly communicated to the public
8	as 7 plus subsidies are made available to implement the plans
9	as 8 plus annual reports are provided on the progress of the implementation and/or any other activity indicating that this is a very high priority implemented at the level of the local community
10	as 9 and the activity is in place for = 3 years

Example. In Anycity there is no bike sharing schemes. There is park and ride scheme and car sharing scheme. There is investment in cycling and cycle paths. There are 6 charging stations for electric cars. Therefore Anycity is given value 10.

Where to get the data:

Data needs to be researched locally.

Indicator 12 evaluation

Description	**Value**
Clean energy transport	

Indicator 12 - CLEAN ENERGY TRANSPORT – direct links

Water	Clean transportation reduces water pollution and purification costs
Waste	no direct links identified
Energy	Clean energy means of transport reduce the exploitation of other energy sources
Transport	
ICT	ICT can help to plan to achieve higher level of efficiency of transport

A.2.6 Indicator 13 - TRANSPORT-RELATED POLLUTIONS

Principal: Air pollutant emissions (Carbon monoxide (CO), Nitrogen oxides (NO_x), Particulates (PM_{10}) - airbourne particulate matter with aerodynamic diameter less than 10 micrometres, Particulates ($PM_{2.5}$) - airbourne particulate matter with aerodynamic diameter less than 2.5 micrometres, Benzene, 1,3-butadiene, Lead (Pb), Sulphur oxides (SO_x)) from transport. A lower indicator score is given where the pollutant emissions are greater.

How to calculate:

Each of air pollutant will be compared with the international range. Therefore:

- Sulphur oxides (SO_x):
  The lowest average emissions is 0.114 kg/cap/yr.
  The highest average emissions is 2.753 kg/cap/yr. Therefore:
  $$\mathbf{SO_x = \frac{2.753 - A}{2.753 - 0.114} \times 10}$$
  where *A* is the emissions from the city (kg/cap/yr).
- Nitrogen oxides (NO_x):
  The lowest average emissions is 4.095 kg/cap/yr.
  The highest average emissions is 36.53 kg/cap/yr. Therefore:
  $$\mathbf{NO_x = \frac{36.53 - B}{36.53 - 4.095} \times 10}$$
  where *B* is the emissions from the city (kg/cap/yr).
- Ammonia (NH_3):
  The lowest average emissions is 0.021 kg/cap/yr.
  The highest average emissions is 0.337 kg/cap/yr. Therefore:
  $$\mathbf{NH_3 = \frac{0.337 - C}{0.337 - 0.021} \times 10}$$
  where *C* is the emissions from the city (kg/cap/yr).
- Non-methane volatile organic compounds:
  The lowest average emissions is 0.432 kg/cap/yr.
  The highest average emissions is 5.643 kg/cap/yr. Therefore:
  $$\mathbf{\text{Non-mth} = \frac{5.643 - D}{5.643 - 0.432} \times 10}$$
  where *D* is the emissions from the city (kg/cap/yr).
- Particulates (PM_{10}):
  The lowest average emissions is 0.169 kg/cap/yr.
  The highest average emissions is 2.197 kg/cap/yr. Therefore:
  $$\mathbf{PM_{10} = \frac{2.197 - E}{2.197 - 0.169} \times 10}$$
  where *E* is the emissions from the city (kg/cap/yr).

The indicator is calculated as an average of all sub-indicators:

$\mathbf{Indicator\ 13 = (SO_x + NO_x + NH_3 + Non\text{-}mth + PM_{10})/5}$

Example. For Anycity the sub-indicators are as follows: $\mathbf{SO_x} = 9.56$, $\mathbf{NO_x} = 9.29$, $\mathbf{NH_3} = 7.12$, $\mathbf{Non\text{-}mth} = 9.48$, $\mathbf{PM_{10}} = 8.89$. Therefore:

$\text{Indicator 13} = (9.56 + 9.29 + 9.48 + 7.33 + 8.89)/5 = 8.91$

Where to get the data:

https://www.gov.uk/government/collections/energy-and-environment-statistics

http://www.eea.europa.eu/data-and-maps/indicators/transport-emissions-of-air-pollutan
transport-emissions-of-air-pollutants-9

http://ec.europa.eu/eurostat/web/environment/air-emissions-inventories/database

Indicator 13 evaluation

Description	Units	Value	Code in formula
Sulphur oxides emissions in the city	t		**A**
$\mathbf{SO_x = \frac{2.753 - A}{2.753 - 0.114} \times 10}$	–		$\mathbf{SO_x}$
Nitrogen oxides emissions in the city	kg/cap/yr		**B**
$\mathbf{NO_x = \frac{36.53 - B}{36.53 - 4.095} \times 10}$	–		$\mathbf{NO_x}$
Ammonia emissions in the city	kg/cap/yr		**C**
$\mathbf{NH_3 = \frac{0.337 - C}{0.337 - 0.021} \times 10}$	–		$\mathbf{NH_3}$
Non-methane volatile organic compounds emissions in the city	kg/cap/yr		**D**
$\mathbf{Non\text{-}mth = \frac{5.643 - D}{5.643 - 0.432} \times 10}$	–		$\mathbf{Non\text{-}mth}$
Particulates (PM_{10}) emissions in the city	kg/cap/yr		**E**
$\mathbf{PM_{10} = \frac{2.197 - E}{2.197 - 0.169} \times 10}$	–		$\mathbf{PM_{10}}$
Formula		$\mathbf{(SO_x + NO_x + NH_3 + Non\text{-}mth + PM_{10})/5}$	
Result			

Indicator 13 - TRANSPORT-RELATED POLLUTIONS – direct links

Water	Pollutants from road surfaces contaminate drainage water
Waste	no direct links identified
Energy	no direct links identified
Transport	
ICT	ICT can improve efficiency of managing transport in the city

A.2.7 Indicator 14 - TRANSPORT INFRASTRUCTURE INVESTMENT

Principal: A measure of the investment in the transport infrastructure. A lower indicator score is given where the investment is lower.

How to calculate:

The infrastructure investment is an indication of the commitment to regularly invest in the transport infrastructure. Investment can be in:

- a new infrastructure
- maintaining
- and refurbishing the existing one.

The investment in the city/region by capita, **X** is calculated as the investment in the city/region **A** divided by local population of the city/region **B**:

$$\mathbf{X = A/B}$$

Subsequently, the investment in the city/region per capita **X** is divided by GDP per capita in the country **Y**.

The average lowest percentage of investment is 0.02%.

The average highest percentage of investment is 3.89%.

Therefore, the indicator is calculated as follows:

$$\mathbf{Indicator\ 14 = \frac{100 \times X/Y - 0.02}{3.89 - 0.02} \times 10}$$

Example: In Anycity £319.20 million was invested in the transport infrastructure (in 2014/15). Population in the area is 4.533 million. Therefore the investment per capita **X** is:

$$X = 319.20/4.533 = 70[£/\mathrm{cap}]$$

GDP per capita in the UK is £30074.59 [£/cap]. Therefore:

$$\mathrm{Indicator\ 14} = \frac{100 \times 70/30074.59 - 0.06}{2.29 - 0.06} \times 10 = 0.78$$

Comment: the principle is the same as indicator 7.

Where to get the data:

Data for cities needs to be researched locally.

Date for countries:

http://data.worldbank.org/indicator/IE.PPI.TRAN.CD

Indicator 12 evaluation

Description	Units	Value	Code in formula
Investment in the transport infrastructure per capita (in the city/region)	£(€)/cap		X
GDP per capita (in the country)	£(€)/cap		Y
Formula		$\frac{100 \times X/Y - 0.02}{3.89 - 0.02} \times 10$	
Result			

Indicator 14 - TRANSPORT INFRASTRUCTURE INVESTMENT – direct links

Water	Investment in transport infrastructure, e.g. by refurbishing roads, may prompt water utilities to carry out necessary works
Waste	no direct links identified
Energy	Investment in transport infrastructure may prompt energy utilities to carry out necessary works
Transport	
ICT	Investment in transport infrastructure may prompt ICT companies to carry out necessary works

A.3 ICT Indicators

A.3.1 Indicator 15 - ICT ACCESS

Principal: The ICT access is a measure of access to information and communication technology (ICT) in the city. A lower indicator score is given where the ICT access is lower.

How to calculate:

Following sub-indicators need to be calculated and an average value is taken.

- Mobile-cellular telephone subscriptions per 100 inhabitants, where **X** is the number of mobile-cellular telephone subscriptions per 100 inhabitants in the city: $\mathbf{A = 10 \times X/120}$
- International Internet bandwidth (bit/s) per Internet user, where **Y** is the International Internet bandwidth (bit/s) per Internet user in the city: $\mathbf{B = 10 \times Y/787,260}$
- Proportion of households with a computer, where **Z** is the percentage of households with a computer in the city: $\mathbf{C = Z/10}$
- Proportion of households with Internet access, where **Q** is the percentage of households with Internet access in the city: $\mathbf{D = Q/10}$

Therefore, the indicator is calculated as follows:

$\mathbf{Indicator\ 15 = (A + B + C + D)/4}$

Example. For Anycity :

Number of mobile-cellular telephone subscriptions per 100 inhabitants: **X = 124**. Therefore:

$\mathbf{A} = 10 \times 124/120 = 10$

International Internet bandwidth (bit/s) per Internet user: **Y = 352,583**. Therefore:

$\mathbf{B} = 10 \times 352,583/787,260 = 4.5$

Percentage of households with a computer: **Z = 88.2 %**. Therefore:

$\mathbf{C} = 88.2/10 = 8.8$

Percentage of households with Internet access: **Q = 84 %**. Therefore:

$\mathbf{D} = 84/10 = 8.4$

The indicator is calculated as follows:

$\text{Indicator } 15 = (10 + 4.5 + 8.8 + 8.4)/4 = 7.9$

Where to get the data:

Data needs to be researched locally.

Indicator 15 evaluation

Description	Units	Value	Code in formula
Number of mobile-cellular telephone subscriptions per 100 inhabitants in the city	No.		**X**
Mobile-cellular telephone subscriptions per 100 inhabitants $\mathbf{A = 10 \times X/120}$	–		**A**
International Internet bandwidth per Internet user in the city	bit/s		**Y**
International Internet bandwidth per Internet user $\mathbf{B = 10 \times Y/787,260}$	–		**B**
Percentage of households with a computer in the city	%		**Z**
Proportion of households with a computer $\mathbf{C = Z/10}$	–		**C**
Percentage of households with Internet access in the city	%		**Q**
Proportion of households with Internet access $\mathbf{D = Q/10}$	–		**D**
Formula		$\mathbf{\frac{A+B+C+D}{4}}$	
Result			

Indicator 15 - ICT ACCESS – direct links

Water	People have more tools to get informed about water topics. It increases awareness
Waste	People have more tools to get informed about waste topics. It increases awareness
Energy	People have more tools to get informed about energy topics. It increases awareness
Transport	Access to information about public transport, traffic, available routes
ICT	

A.3.2 Indicator 16 - ICT USE HOUSEHOLD

Principal: The ICT use is a measure of use of information and communication technology (ICT) in the city. A lower indicator score is given where the ICT use is lower.

How to calculate:

Following sub-indicators need to be calculated and an average value is taken.

- Proportion of individuals using the Internet, where **X** is the percentage of population in the city using the Internet: $\mathbf{A = X/10}$
- Fixed (wired)-broadband subscriptions per 100 inhabitants, where **Y** is the number of fixed (wired)-broadband subscriptions per 100 inhabitants in the city: $\mathbf{B = 10 \times Y/60}$
- Wireless-broadband subscriptions per 100 inhabitants, where **Z** is the number of wireless-broadband subscriptions per 100 inhabitants in the city: $\mathbf{C = Z/10}$

Therefore, the indicator is calculated as follows:

$\mathbf{Indicator\ 16 = (A + B + C)/3}$

Example. For Anycity :

Percentage of individuals using the Internet: **X = 89.9**. Therefore:

$\mathbf{A} = 89.9/10 = 9.0$

Number of fixed (wired)-broadband subscriptions per 100 inhabitants: **Y = 37.8**. Therefore:

$\mathbf{B} = 10 \times 37.8/60 = 6.3$

Number of wireless-broadband subscriptions per 100 inhabitants: **Z = 79.6**. Therefore:

$\mathbf{C} = 79.6/10 = 8.0$

The indicator is calculated as follows:

$\mathrm{Indicator\ 16} = (9 + 6.3 + 8)/3 = 7.7$

Where to get the data:

Data needs to be researched locally.

Indicator 16 evaluation

Description	Units	Value	Code in formula
Percentage of population in the city using the Internet	%		X
Proportion of individuals using the Internet $\mathbf{A} = \mathbf{X}/10$	–		A
Number of fixed (wired)-broadband subscriptions per 100 inhabitants in the city	No.		Y
Fixed (wired)-broadband subscriptions per 100 inhabitants $\mathbf{B} = 10 \times \mathbf{Y}/60$	–		B
Number of wireless-broadband subscriptions per 100 inhabitants in the city	No.		Z
Wireless-broadband subscriptions per 100 inhabitants $\mathbf{C} = \mathbf{Z}/10$	–		C
Formula		$\frac{\mathbf{A}+\mathbf{B}+\mathbf{C}}{3}$	
Result			

Indicator 16 - ICT USE HOUSEHOLDS – direct links

Water	People have more tools to get informed about water topics. It increases awareness
Waste	People have more tools to get informed about waste topics. It increases awareness
Energy	People have more tools to get informed about energy topics. It increases awareness
Transport	People have more tools to get informed about transport topics. It increases awareness
ICT	

A.3.3 Indicator 17 - ICT USE WATER UTILITIES

Principal: A measure of ICT implementation at the city utility level. A lower indicator score is given where there are less ICT tools implemented.

How to calculate:

Description	Score (0-10) evaluated locally	Comments
Operation		e.g. SCADA system, energy management
Maintenance		e.g. asset management data base and GIS
Planning and design		e.g. optimisation, GIS interface
Customer service		e.g. smart metering

For Anycity :

- Smartphone app “Love Anycity ” where people can report floods, leaks, etc.
- Flood warning system
- Flow gauges and rainfall gauges to collect data
- Engaging with communities in flood risk areas; flood wardens are chosen from the local community
- New buildings have meters for billing purposes
- Water management system within buildings to prevent leaks
- Leakage detection for district heating pipelines
- Leakage detection for pipelines
- SWIMS – Severe Weather Impacts Monitoring System. Each council service will log the impacts of, and its responses to, severe weather events onto the online data capture facility

Therefore in Anycity :

Description	Score (0-10) evaluated locally	Comments
Operation	10	e.g. SCADA system, energy management
Maintenance	10	e.g. asset management data base and GIS
Planning and design	7	e.g. optimisation, GIS interface
Customer service	2	e.g. smart metering

$\text{Indicator } 17 = (10 + 10 + 7 + 2)/4 = 7.3$

Indicator 17 evaluation

Description	**Value**
ICT USE WATER UTILITIES	

Where to get the data:
Data needs to be researched locally.

Comment: This indicator should be assessed by an expert.

Indicator 17 - ICT USE WATER UTILITIES – direct links

Water	
Waste	no direct links identified
Energy	The ICT use by water utilities can help them in achieving an optimized management with potential saving in energy consumption
Transport	no direct links identified
ICT	

A.3.4 Indicator 18 - ICT USE ENERGY UTILITIES

Principal: A measure of ICT implementation at the city utility level. A lower indicator score is given where there are less ICT tools implemented.

How to calculate:

Description	Score (0-10) evaluated locally	Comments
Operation		e.g. SCADA system, energy management
Maintenance		e.g. asset management data base and GIS
Planning and design		e.g. optimisation, GIS interface
Customer service		e.g. smart metering

For Anycity :

- 5500 homes with smart meters for gas and electricity installed. All 123,000 houses offered a smart meter by 2020.

Therefore in Anycity :

Description	Score (0-10) evaluated locally	Comments
Operation	10	e.g. SCADA system, energy management
Maintenance	10	e.g. asset management data base and GIS
Planning and design	9	e.g. optimisation, GIS interface
Customer service	6	e.g. smart metering

$\text{Indicator } 18 = (10 + 10 + 9 + 6)/4 = 8.6$

Indicator 18 evaluation

Description	**Value**
ICT USE ENERGY UTILITIES	

Where to get the data:

Data needs to be researched locally.

Comment: This indicator should be assessed by an expert.

Indicator 18 - ICT USE ENERGY UTILITIES – direct links

Water	no direct links identified
Waste	no direct links identified
Energy	
Transport	no direct links identified
ICT	

A.3.5 Indicator 19 - ICT USE TRANSPORT

Principal: A measure of ICT implementation at the city utility level. A lower indicator score is given where there are less ICT tools implemented.

How to calculate:

Description	Score (0-10) evaluated locally	Comments
Operation		e.g. coverage of installation of road sensing terminals and traffic control in the city
Maintenance		e.g. is there ICT system for planning the road maintenance and public transport vehicles?
Planning and design		e.g. is there ICT system for planning transport infrastructure expansion and improvement?
Customer service		e.g. mobile bus tickets, online feedback forms

For Anycity :

Description	Score (0-10) evaluated locally	Comments
Operation	4	e.g. coverage of installation of road sensing terminals and traffic control in the city
Maintenance	4	e.g. is there ICT system for planning the road maintenance and public transport vehicles?
Planning and design	4	e.g. is there ICT system for planning transport infrastructure expansion and improvement?
Customer service	7	e.g. mobile bus tickets, online feedback forms

$$\text{Indicator } 19 = (4 + 4 + 4 + 7)/4 = 4.8$$

Indicator 19 evaluation

Description	**Value**
ICT USE TRANSPORT	

Where to get the data:

Data needs to be researched locally.

Comment: This indicator should be assessed by an expert.

Indicator 19 - ICT USE TRANSPORT – direct links

Water	no direct links identified
Waste	no direct links identified
Energy	The use of ICT in transport management can help reducing travel times and energy consumption
Transport	
ICT	

A.3.6 Indicator 20 - ICT USE WASTE MANAGEMENT

Principal: A measure of ICT implementation at the city utility level. A lower indicator score is given where there are less ICT tools implemented.

How to calculate:

Description	Score (0-10) evaluated locally	Comments
Operation		e.g. ICT system for logistics of waste collection
Maintenance		e.g. is there ICT system for the pro-active maintenance of waste collection infrastructure?
Planning and design		e.g. is there ICT system for planning future enhancements and improvement of waste infrastructure?
Customer service		e.g. smart labelling of waste bags, online feedback forms, citizen engagement

Example. For Anycity :

- Waste truck management system
- Waste operation system (record how much waste is produced)
- Biffa Waste Services works with CMS SupaTrak to reduce their fuel costs and lower their vehicle carbon emissions using EcoTrak fuel saving technology that is used to identify individual driver behaviuor and trends (e.g. speed, real time MPG, green band driving)

Therefore in Anycity :

Description	Score (0-10) evaluated locally	Comments
Operation	7	e.g. ICT system for logistics of waste collection
Maintenance	4	e.g. is there ICT system for the pro-active maintenance of waste collection infrastructure?
Planning and design	3	e.g. is there ICT system for planning future enhancements and improvement of waste infrastructure?
Customer service	8	e.g. smart labelling of waste bags, online feedback forms, citizen engagement

$\text{Indicator } 20 = (7+4+3+8)/4 = 5.5$

Indicator 20 evaluation

Description	**Value**
ICT USE WASTE MANAGEMENT	

Where to get the data:

Data needs to be researched locally.

Comment: This indicator should be assessed by an expert.

Indicator 20 - ICT USE WASTE MANAGEMENT – direct links

Water	no direct links identified
Waste	
Energy	no direct links identified
Transport	no direct links identified
ICT	

A.3.7 Indicator 21 - DIGITAL PUBLIC SERVICE

Principal: A measure of ICT implementation within public administration (percentage of Internet users that have engaged with the public administration and exchanged filled forms online) and health system. A lower indicator score is given where there are less ICT tools implemented.

How to calculate:

Following sub-indicators need to be calculated:

- Proportion of eGovernment Users, **A**. Percentage of individuals sending filled forms over the internet to public authorities, or contacting public authorities by e-mail or website, or obtaining information from public authorities over the internet **X** divided by 10:

$\mathbf{A = X/10}$

- Medical Data Exchange, **B**. Percentage of general practitioners using electronic networks to exchange medical data with other health care providers and professionals and to transfer prescriptions to pharmacists, **Y**, divided by 10:

$\mathbf{B = Y/10}$

Therefore, the indicator is calculated as follows:

$\mathbf{Indicator\ 21 = (A + B)/2}$

Example. For Anycity :

Percentage of individuals sending filled forms over the internet to public authorities or contacting public authorities by e-mail or website, or obtaining information from public authorities over the internet: **X = 46 %**. Therefore:

$\mathbf{A} = 46/10 = 4.6$

Percentage of general practitioners using electronic networks to exchange medical data with other health care providers and professionals and to transfer prescriptions to pharmacists: **Y = 30 %**. Therefore:

$\mathbf{B} = 30/10 = 3$

The indicator is calculated as follows:

$\text{Indicator } 21 = (4.6 + 3)/2 = 3.8$

Where to get the data:

Data needs to be researched locally.

Indicator 21 evaluation

Description	**Units**	**Value**	**Code in formula**
Percentage of individuals sending filled forms over the internet to public authorities, or contacting public authorities by e-mail or website, or obtaining information from public authorities over the internet	%		**X**
Proportion of eGovernment Users $\mathbf{A = X/10}$	–		**A**
Percentage of individuals sending filled forms over the internet to public authorities or contacting public authorities by e-mail or website, or obtaining information from public authorities over the internet	%		**Y**
Medical Data Exchange $\mathbf{B = Y/10}$	–		**B**
Formula		$\mathbf{(A + B)/2}$	
Result			

Indicator 21 - DIGITAL PUBLIC SERVICE – direct links

Water	no direct links identified
Waste	no direct links identified
Energy	no direct links identified
Transport	Digital public services imply a reduced number of visits of customers and citizens to public offices, with benefits in terms of traffic congestion
ICT	

A.3.8 Indicator 22 - INVESTMENT IN ICT INFRASTRUCTURE

Principal: A measure of the investment in the ICT infrastructure. A lower indicator score is given where the investment is lower.

How to calculate:

The infrastructure investment is an indication of the commitment to regularly invest in the ICT infrastructure. Investment can be in:

- a new infrastructure
- maintaining
- and refurbishing the existing one.

The investment in the city/region by capita, **X** is calculated as the investment in the city/region **A** divided by local population of the city/region **B**:

$$\mathbf{X = A/B}$$

Subsequently, the investment in the city/region per capita **X** is divided by GDP per capita in the country **Y**.

The average lowest percentage of investment is 0.09%.

The average highest percentage of investment is 1.5%.

Therefore, the indicator is calculated as follows:

$$\mathbf{Indicator\ 22 = \frac{100 \times X/Y - 0.09}{1.5 - 0.09} \times 10}$$

Example: In Anycity £544 million was invested in the ICT infrastructure (in 2014/15). Population in the area is 4.533 million. Therefore the investment per capita **X** is:

$$X = 544/4.533 = 120[\text{£}/\mathrm{cap}]$$

GDP per capita in the UK is £30074.59 [£/cap]. Therefore:

$$\mathrm{Indicator\ 22} = \frac{100 \times 120/30074.59 - 0.09}{1.5 - 0.09} \times 10 = 2.2$$

Comment: the principle is the same as indicator 7 and 12.

Where to get the data:

Data for cities needs to be researched locally.

Data for countries:

http://data.worldbank.org/indicator/IE.PPI.TELE.CD/countries

Indicator 22 evaluation

Description	**Units**	**Value**	**Code in formula**
Investment in the ICT infrastructure per capita (in the city/region)	£(€)/cap		**X**
GDP per capita (in the country)	£(€)/cap		**Y**
Formula		$\frac{100 \times X/Y - 0.09}{1.5 - 0.09} \times 10$	
Result			

Indicator 22 - ICT INFRASTRUCTURE INVESTMENT – direct links

Water	investment in ICT infrastructure, e.g. by refurbishing roads, may prompt water utilities to carry out necessary works
Waste	no direct links identified
Energy	investment in ICT infrastructure, e.g. by refurbishing roads, may prompt energy utilities to carry out necessary works
Transport	road works associated with investment in the ICT infrastructure may disturb transport
ICT	

References

[1] World Health Organization (WHO). http://www.who.int/en/. Accessed: 2015/10/21.

[2] United Nations (UN). http://esa.un.org/unpd/wpp/. Accessed: 2015/10/21.

[3] C. J. Van Leeuwen, S. H. A. Koop, and R. M. A. Sjerps. City Blueprints: baseline assessments of water management and climate change in 45 cities. *Environment, Development and Sustainability*, pages 1–16, 2015.

[4] European Green City Index. Assessing the environmental impact of Europe's major cities, 2009. A research project conducted by the Economist Intelligence Unit, sponsored by Siemen.

[5] ISO 37120:2014(E). Sustainable development of communities — indicators for city services and quality of life, 2014.

[6] Planning for Energy Efficient Cities. http://www.pleecproject.eu/. Accessed: 2015/10/21.

[7] The Digital Economy and Society Index (DESI). http://europa.eu/!hV47VV. Accessed: 2015/10/21.

[8] Carbon Trust). http://www.carbontrust.com/. Accessed: 2015/10/21.

[9] The Organisation for Economic Co-operation and Development (OECD). Air and climate. https://data.oecd.org/air/air-and-ghg-emissions.htm. Accessed: 2015/10/21.

[10] Department of Energy & Climate Change. Annual Fuel Poverty Statistics. www.gov.uk/decc, 2009. Report.

[11] Eurostat. Final energy consumption by produc. http://ec.europa.eu/eurostat/tgm/table.do?tab=table&init=1&language=en&pcode=ten00095&plugin=1. Accessed: 2015/10/21.

[12] Eurostat. Electricity generated from renewable sources. http://ec.europa.eu/eurostat/web/energy/data/main-tables. Accessed: 2015/10/21.

[13] ITU Telecommunication Standardization Sector. Key performance indicators related to the sustainability impacts of information and communication technology in smart sustainable cities, 2015.

[14] The World Bank. Investment in energy with private participation. http://data.worldbank.org/indicator/IE.PPI.ENGY.CD. Accessed: 2015/10/21.

[15] Trade Union Congress. https://www.tuc.org.uk/. Accessed: 2015/10/21.

[16] NationMaster. Statistics for Transport. http://www.nationmaster.com/country-info/stats/Transport/Commute/Time-spent. Accessed: 2015/10/21.

[17] World Health Organization (WHO). Global status report on road safety 2013: supporting a decade of action. www.who.int, 2013. Report.

[18] Eurostat. Air emission inventories. http://ec.europa.eu/eurostat/web/environment/air-emissions-inventories/database. Accessed: 2015/10/21.

[19] The World Bank. Investment in transport with private participation. http://data.worldbank.org/indicator/IE.PPI.TRAN.CD. Accessed: 2015/10/21.

[20] International Telecommunication Union. http://www.itu.int/. Accessed: 2015/10/21.

[21] The World Bank. Investment in telecoms with private participation. http://data.worldbank.org/indicator/IE.PPI.TELE.CD/countries. Accessed: 2015/10/21.