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Issue 3

BRIDGE newsletter

Editorial

The FP7 project BRIDGE** (sustainaBle uRban plannIng Decision support accountinG for urban mEtabolism) is a joint effort of 14 European Organizations aiming at incorporating sustainability aspects in urban planning processes, accounting for some well recognised relations between **urban metabolism** and **urban structure**. **BRIDGE** was launched in 2008 in order to **assist urban planners to present and evaluate planning alternatives towards a sustainable city.

The 3rd issue of the BRIDGE newsletter includes articles presenting the progress and achievements of the project regarding models' first simulation and results at case study cities, as well as an article on the final environmental and socio-economic sustainability indicators to be implemented in the BRIDGE DSS.

BRIDGE partners:

1. Foundation for Research and Technology - Hellas (FORTH), Greece
2. King's College London (KCL), United Kingdom
3. Consiglio Nazionale delle Ricerche (CNR), Italy
4. Instytut Ekologii Terenów Uprzemysłowionych (IETU), Poland
5. Technical University of Madrid (UPM), Spain
6. University of Aveiro (UAVR), Portugal
7. University of Basel (UBAS), Switzerland
8. Trinity College Dublin (TCD), Ireland
9. University of Helsinki (UHEL), Finland
10. National and Kapodistrian University of Athens (NKUA), Greece
11. Centro Euro-Mediterraneo per i Cambiamenti Climatici S.c.a.r.l. (CMCC), Italy
12. Météo France Centre National De Recherches Météorologiques (CNRM), France
13. DLO/Alterra B.V. (ALTERRA), The Netherlands
14. University of Southampton (SOTON), United Kingdom

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Introduction

BRIDGE aims at illustrating the advantages of considering environmental issues in urban planning and focuses on specific urban metabolism components (**energy**, **water**, **carbon**, **pollutants**). BRIDGE integrates the development of numerical tools and methodologies for the analysis of fluxes between a city and its environment with its validation and application in terms of future development alternatives, based on environmental and socio-economic indicators for baseline and extreme situations. Therefore, the innovation of BRIDGE lies in the development of a **Decision Support System (DSS)** integrating the bio-physical observations with socio-economic issues. It allows end-users to evaluate several urban planning alternatives based on their initial identification of planning objectives. In this way, sustainable planning strategies will be analysed based on quantitative assessments of energy, water, carbon and pollutants fluxes.

BRIDGE involves five European cities as case studies: a high latitude with rapid urbanization city that requires a substantial amount of energy for heating (Helsinki, Finland); a low latitude Mediterranean city that requires a substantial amount of energy for cooling (Athens, Greece); a representative European megacity (London, United Kingdom); a representative European old city with substantial cultural heritage (Firenze, Italy) and a representative Eastern European city with dynamic planning process reflecting the economical, social, and political changes held within last two decades (Gliwice, Poland).

The project so far

The baselines of the methodology specification have been fully set to identify the current understanding that has to do with urban metabolism and the users' needs. The urban metabolism components fluxes are measured and modelled at local scale and their spatio-temporal distributions are estimated.

The BRIDGE database has already been developed and it is being updated frequently to include any available data. More specifically, in-situ measurements were performed in each of the five case studies cities of BRIDGE (meteorological parameters, fluxes of energy, particulate matter, etc.), according to the measurement protocols that have already been produced. Remote sensing data are also available from either flight campaigns or satellites. GIS and socio-economic data were also collected with the valuable help of the local authorities in the five case studies.

The selection of models for implementation in the DSS has been completed and their requirements and their relation to the project have been examined and documented. The models suitable for the BRIDGE purposes were flagged as "on-line" or "off-line" whether they are running in true time in the DSS or not. Different types of models from meso-scale air quality models to urban canopy models will be used in the framework of BRIDGE. The cascade modelling technique from large to local scale is the main methodology applied in BRIDGE. This approach allows estimating the pollutant concentrations and the fluxes associated to varying geographical extents of urban development scenarios.

The first dataset has been fed to the models and some model simulation results are already available. Data are constantly being passed for model implementation. Mesoscale air quality model with urban and canopy parameterisation WRF-UCM basic runs have already been completed for the five case studies. The simulation results were passed to run the chemical modules (such as CMAQ or CAMx) and to feed the meteorological information needed for running the on-line models for hydrology (SIMGRO), air quality (URBAIR) and urban metabolism (LUMPS and SURFEX).

A Cellular Automata (CA) module is integrated in BRIDGE DSS for the simulation of land use dynamics. The CA servers the purpose of determining future spatial distribution of city-wide land uses, taking into account the planning alternatives considered in the case studies and the local interaction between different land-uses, as well as the physical, environmental and institutional factors and other relevant characteristics characterizing each cell.

An addition to the CA software simulation framework was made by implementing an algorithm for estimating the road network load based on a long-run origin destination transportation model, using the OpenStreetMap road network database. This is an important addition to the CA simulation model since it is the basis for building scenarios of city-wide long-run impacts of new urban developments on the use of the transportation network, which is a relevant environmental aspect as well as a factor in the urban metabolism.

Some of the outputs of the above models lead to indicators which address the state of the urban environment. The indicators to be used in the DSS were specified during the 'Community of Practice' meetings, where local decision makers and scientists exchange knowledge and experience. Therefore, the end-users decide on the urban planning priorities and the sustainability objectives that correspond to their needs and determine objectives' relative importance.

A beta version of the BRIDGE DSS is currently available including: a) a database holding the data available to date, b) four "on-line" models (URBAIR, LUMPS, SURFEX and SIMGRO), and c) a graphical user interface, facilitating user interaction (defining preferences as well as presenting the model simulation results). Results are presented in an overview presentation (which includes individual indicator values, the spatial distribution of such values, and the total score for the alternative), enabling end-users to access the merits of each planning alternative and eventually to perform sensitivity analyses, by changing the values of indicators' weights.

The beta version is constantly updated with simulation results and the interaction with the end-users provides feedback in order to develop the first prototype of the BRIDGE DSS. The Graphical User Interface is also updated constantly to be user friendly, and a help menu is being developed to guide the user.

In conclusion, the end-user defines the criteria and indicators to be used in the analysis, selects their relative importance and runs the analysis. The analysis results, for every alternative, include: the normalized weights for criteria and indicators; the score of each criterion; a spider

BRIDGE Foresight exercise by Univ. Aveiro

The BRIDGE Foresight exercise will be held next December 8th 2010 in London. The exercise is part of BRIDGE's WP7, dedicated to the DSS application. BRIDGE DSS combines physical data generated by models with socio-economic data provided by statistical sources and by policy makers, in order to assess the presented planning alternatives defined in each case study. Also, in the DSS application it will be essential to define the relative importance ascribed by the end-users to variables which are part of the evaluation algorithm; macro-dimensions, such as climate change, energy shortage and economic performance, present different evolution possibilities which will be discussed using a scenario analysis methodology. Participants of the exercise will analyse the extent to which variables and weights vary accordingly to the presented scenarios.

In this event, experts from the case studies and from BRIDGE team, as well as invited external experts, will discuss how sustainable urban policies can be reflected on the projects under evaluation in each case study. It will also be an excellent opportunity to debate with experts and urban policy practitioners about sustainable urban policies in the near future and how to integrate them in urban planning nowadays.

Venue

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diagram graphically presenting the score of each criterion; indicator values for non-spatial indicators and GIS maps for the spatial indicators and the total assessment value for each assessed alternative.

Planning alternatives are tested and simulated in all case studies cities according to a unifying taxonomy that was defined and based on standardised types of land-uses and the expected degree of constraints. Such taxonomy should be applied to the relevant planning information, which is natively highly heterogeneous among the involved cities reflecting the variability of legal frameworks and planning traditions.

Project meetings and upcoming events

Although the communication between the project participants is almost daily via email, via Skype or via the ftp web based server, there was also an Extended Management Board meeting in Brussels on 14 June 2010 in order to resume the basic points to be presented in the Mid-term review meeting.

The Mid-term Review meeting was also held in Brussels on June 2010 and it was one of the most important milestones of the last 6-month period. The progress of the project was rated as excellent, since the project had fully achieved its objectives and technical goals for the period.

On 9 September 2010, the 10th Management Board Skype-meeting was organized to discuss the project's evolution and focus on future actions of the project. An important technical meeting was organized concerning the tasks of WPs 4, 6 and 7 and it took place in Madrid on 7-8 October 2010. During this meeting the progress of the respective workpackages was presented and decisions were made on their evolution. On 5 November 2010, the 11th Management Board Skype-meeting was organized to prepare the next plenary meeting.

The most important upcoming event is the WP7 Users-Experts meeting (BRIDGE Foresight exercise) and the 4th Progress meeting to be held in London on December 8-10, 2010.

Impact of planning alternatives on air quality in Helsinki case study: URBAIR model application

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In the last decades the study of the urban structure impacts on the quality of life and on the environment became a key issue for urban sustainability. Several studies recognize the importance of urban planning for the improvement of the interactions between different land uses and economic activities, and also towards a more sustainable urban metabolism[1]. Urban structure (sprawl or compact) is intimately related with urban fluxes (incoming and outgoing) of material, energy, information, people, etc.[2]. A major interest relies on understanding the role of planning on induced mobility patterns and thereafter on air quality, particularly related with the increasing use of private cars[3].

To evaluate the impact on air quality due to different planning alternatives for the Helsinki intervention area - the Meri-Rastila - the online model URBAIR was applied. Air quality simulations were performed for Helsinki study case considering the baseline scenario and planning alternatives 1, 2 and 3 accordingly with the available information provided by city planners. The simulations comprise the entire year of 2008 and the pollutants PM_{10}, CO, SO_2 and NO_2.

The URBAIR computational domain, with approximately 4000x4000m^2, with a resolution of 100m centered in the study area. Road traffic is considered the main pollutant source in the study area, therefore no other sources were considered. Traffic emissions were estimated using the Transport Emission Model for Line Sources (TREM)[4], using hourly average traffic flux values obtained from the available vehicles counting data. The emissions and the meteorological conditions were defined on an hourly basis. WRF model outputs (provided by the UPM team) were used to generate the meteorological boundary profiles needed for the URBAIR simulations.

As an example for a specific summer day, in Figure 1 the simulation results are presented for the pollutant PM_{10} in an intercomparison for the baseline scenario and planning alternatives 1, 2 and 3. The positioning and dimension of the new buildings and road network in the different alternatives were obtained from the maps provided by local partners. Due to the fact that estimates of the influence of these alternatives on traffic fluxes are not available these values were calculated as an average of the neighboring roads.

Comparing the results observed in Figure 1 it is possible to conclude that despite the changes on the number of roads and respective traffic fluxes, and also on the number and location of buildings, the different planning alternatives do not induce significant modifications of the dispersion patterns for this particular summer day. However, and according to the simulations, alternatives 2 and 3 have a higher influence over the PM_{10} levels in the intervention area and, particularly in alternative 3, in an area located to the north of the new buildings and roads. In general, PM_{10} concentrations over the domain stay within the limit value established on legislation for 24 hours average (50 $\mu g \cdot m^{-3}$).

URBAIR results for PM_{10}, in accordance with the other pollutants simulated, suggest that urban traffic and buildings placement considered in the different planning alternatives can have an influence on local air quality, i.e., on the number and arrangement of hot–spots, despite no significant increases on concentrations are foreseen. It should be stressed, however, that the accuracy of the input data, especially the expected road traffic fluxes for the new roads, is an important aspect of this analysis.

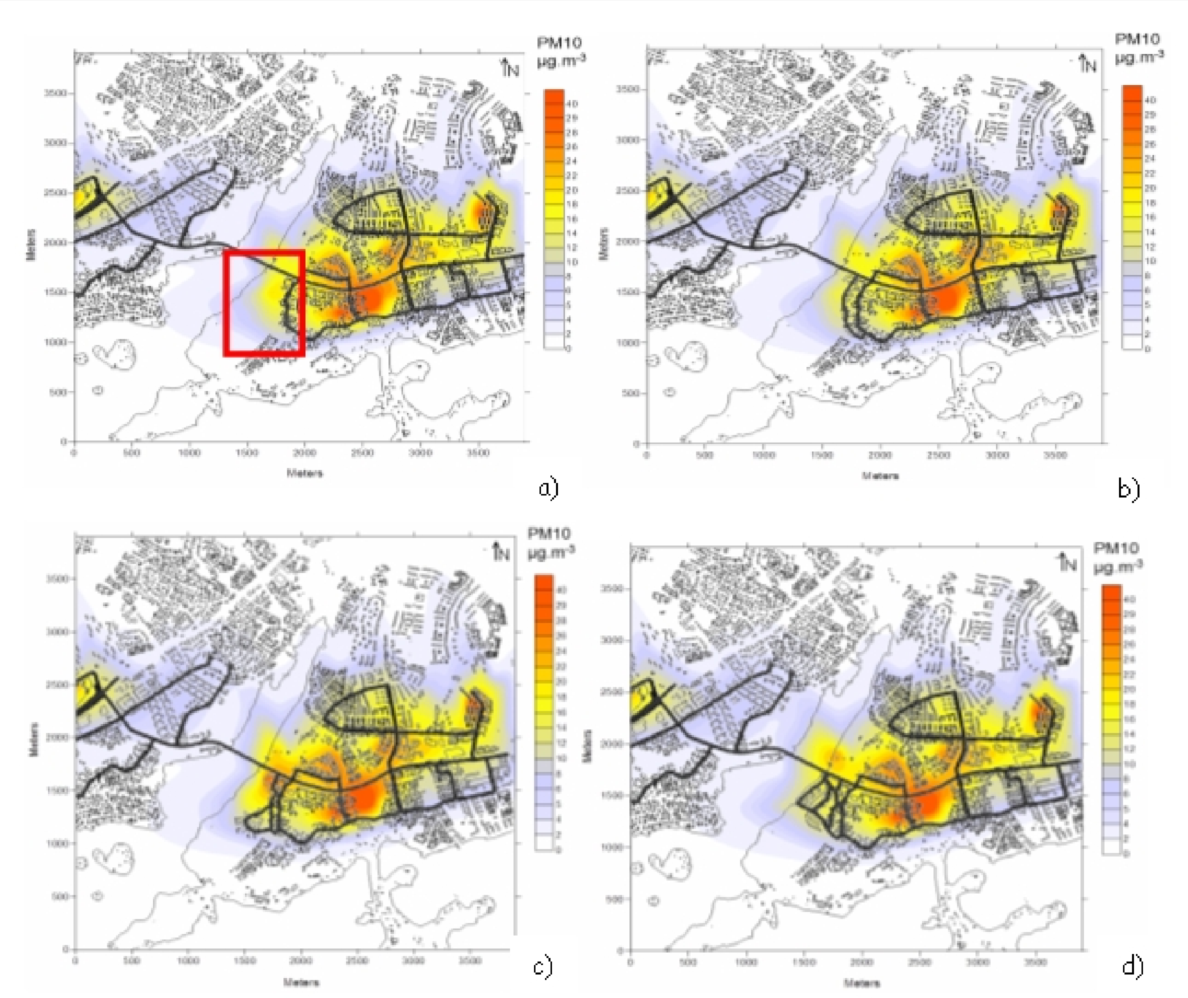

Figure 1. Comparison of 1.5 m high horizontal 24 hour average PM_{10} concentration fields in 25 July 2008 for: a) baseline, b) planning alternative 1, c) planning alternative 2, and d) planning alternative 3. Red rectangle indicates the intervention area.

With the aim of facilitate the integration of URBAIR model into the DSS, and improving the capability and user-friendliness of this tool, a new version was developed that couples the following modules: meteorology; emissions; geographical information (terrain, buildings and sources location); and dispersion. This new version is being integrated and tested.

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Development of a model for urban heat island prediction using neural network techniques

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In the framework of BRIDGE project and in order to predict the heat island effect in the area of Athens, the University of Athens has set up a network of meteorological stations.

Focus is given on the western part of Athens where the municipality of Egaleo, which is the Greek case study area in the framework of Bridge project, is located. In total 20 stations have been placed in 20 municipalities of Athens, including the reference station.

The measured and collected data have been used as input in order to develop the ANN (Artificial Neural Network) model.

Input parameters for the neural network are as follows: i) Date, the date is converted into the numbers of days from the 01 January for the specific year ii) Time, the time is converted into minutes of the day (0 – 1380 min), iii) Ambient temperature (°C) and iv) Global solar radiation (W/m^2).

The estimation or prediction problem using neural network models can be separated into three steps or sub problems: designing the neural network architecture, conducting the learning or training process, and testing.

Three different neural networks, i) Cascade, ii) Elman, and iii) Feed-Forward, are used.

First the experimental site is selected (e.g. Korydalos) and optimal training function, transfer function, right number of hidden layers and neurons for each different neural network are investigated.

Next the results from the three neural networks, for the training and testing data sets are analysed in order to pinpoint the most accurate prediction. In Fig. 1 and Fig. 2, we can observe, the results from the first and second data set (1 and 24 hour prediction horizon) where the optimum results are extracted from Elman followed by Cascade and Feed-Forward.

The difference between the measured and predicted temperature is evaluated. The mean value and the standard deviation (MVSD) of the percentage error (STPE) of each neural network for one hour prediction are as follows: Feed-Forward 2.8±2.2 %, Cascade 2.4±1.5 % and Elman 1.8±1.0 %.

Therefore neural-network-based models are suitable and accurate tools for predicting urban heat island (UHI) intensity of Athens. The experimental results show that the ANNs provided quite satisfactory temperature as well as day maximum temperature predictions.

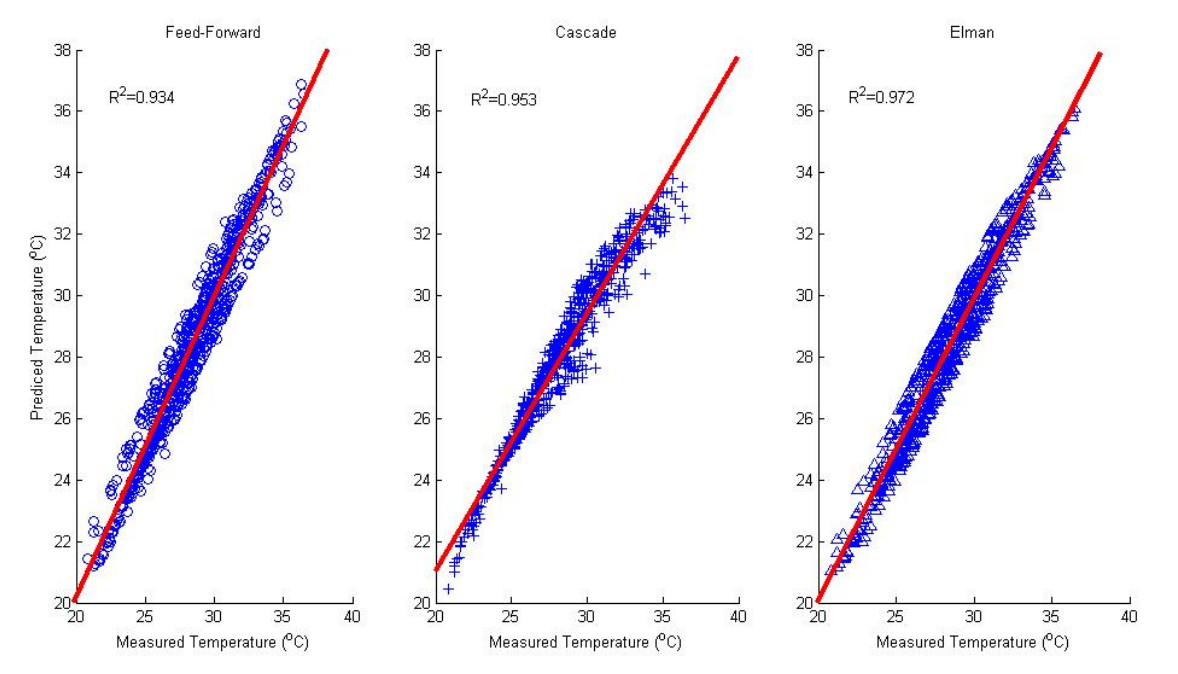

Figure 1: Comparison between different ANN for one-hour prediction horizon.

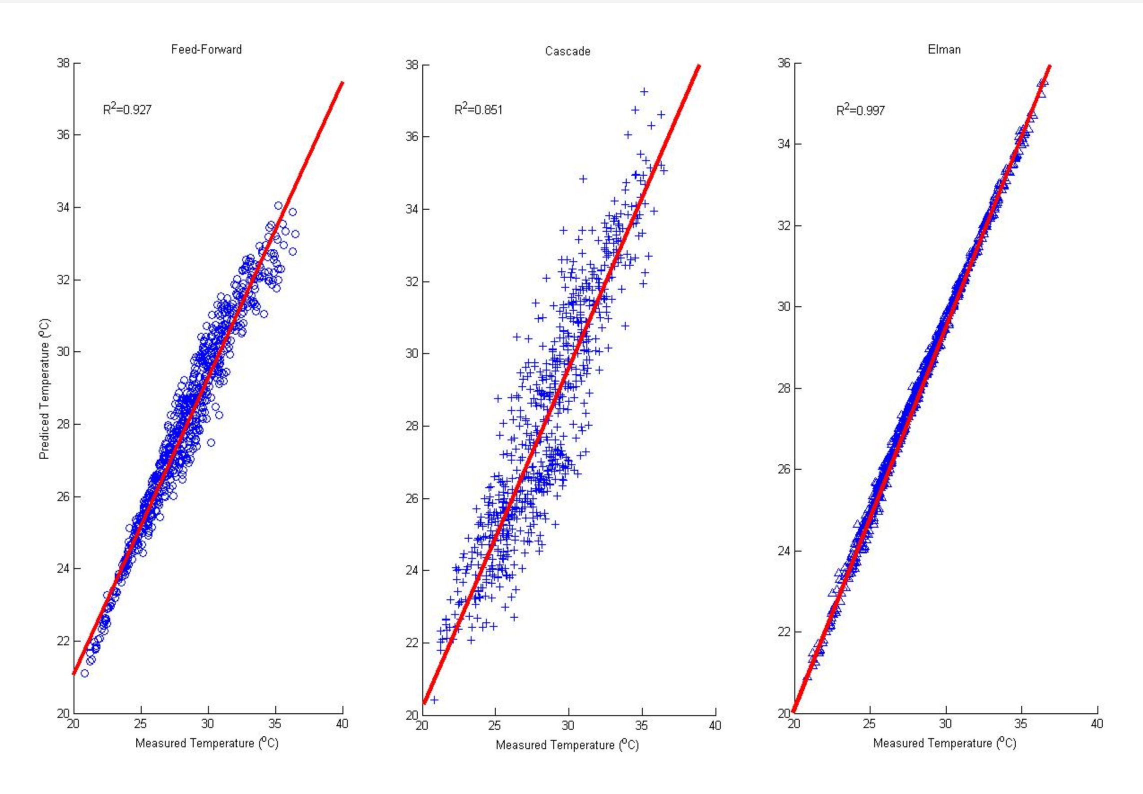

Figure 2: Comparison between different ANN for 24-hour prediction horizon.

The CA Urban Simulation Module

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As for the development of the cellular automata (CA) urban simulation module, the latest months have yielded several progresses. In particular, an algorithm for estimating the road network load has been devised and implemented, based on a long-run origin-destination transportation model [1]. For that purpose, a supplementary development was required to integrate OpenStreetMap road network database within the CA simulation framework [2]. This was an important addition to the CA simulation module since it will form the basis for building future scenarios of city-wide long-run impacts of new urban developments, predicted by the CA simulation, on the usage of the transportation network. Besides being a relevant environmental aspect as well as a factor in the urban metabolism, the estimates of future road network load may provide one of the ways of integration with other simulation models, as they may be fed with that data for further simulations therein.

Also, research efforts have been aimed at improving some specific characteristics of the original urban model [3] to obtain a more suitable representation of the concept of accessibility [4], known to play an essential role in urban transformations.

An additional advancement has been to consolidate and formalise the structure of the data regarding the zoning and planning regulations required for the CA simulation model to produce more reliable projections. Specifically, in accordance to what has been discussed and agreed during the 3rd Progress Meeting in Athens, we have defined a unifying taxonomy based on standardised types of land-uses and the respective expected degree of constraints on permissible transformations from one land-use to another. In order to produce consistently standardised spatial data sets to be used in the CA simulation model, this taxonomy should be applied to the relevant planning information, which natively is highly heterogeneous among the involved cities, reflecting the variability of legal frameworks and planning traditions.

In the near future, the efforts on the CA simulation module will be mainly aimed at testing the preliminary application of the simulation model on the BRIDGE test-cases (Fig. 1).

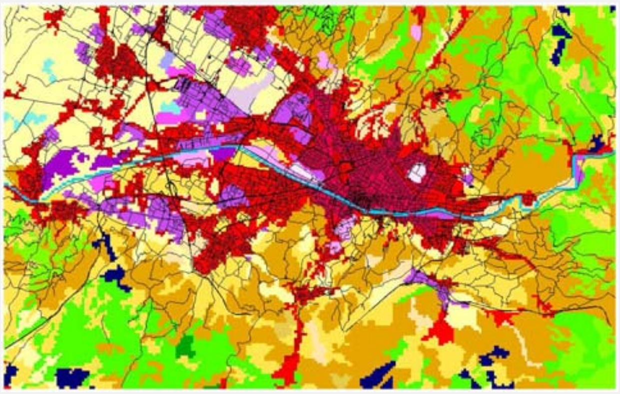

Figure 1: Ten-year projection for the development of the urban area of Florence obtained by the CA model to be included into the BRIDGE DSS.

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Local and regional estimate of urban metabolism

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Urban metabolism is considered as the exchange and transformation of energy and matter between a city and its environment. These fluxes have an important impact on climate change and their study is crucial in the future design and management of cities. Because population and urban areas are expanding, it is therefore important to provide quantitative estimates of the urban metabolism using both observations and modeling of physical flux exchanges. In order to investigate on the energy and mass fluxes exchanged by a touristic European city, the ACASA (Advanced Canopy-Atmosphere-Soil Algorithm) model is applied to simulate fluxes over the Firenze case study (Italy). ACASA simulates fluxes and profiles of heat, water vapor, carbon and momentum within and above canopy using third-order closure equations applied to multiple layers (Fig. 1). ACASA input files include: (1) surface characteristics, (2) meteorological data above the city, and (3) initial conditions. It was already applied over natural and agricultural ecosystems [1] [2]. ACASA was recently modified to properly work in urban environment. Building surfaces are modeled in a similar manner as for leaves and branches, with "leaf-scale" physical parameters representing urban materials. Street-level fluxes of water, heat and carbon are proportional to population density, known estimates of human and mechanical basal metabolism, time of day (peaks at sunrise and sunset), time of week (peaks on Monday and Tuesday), and vehicular flux density.

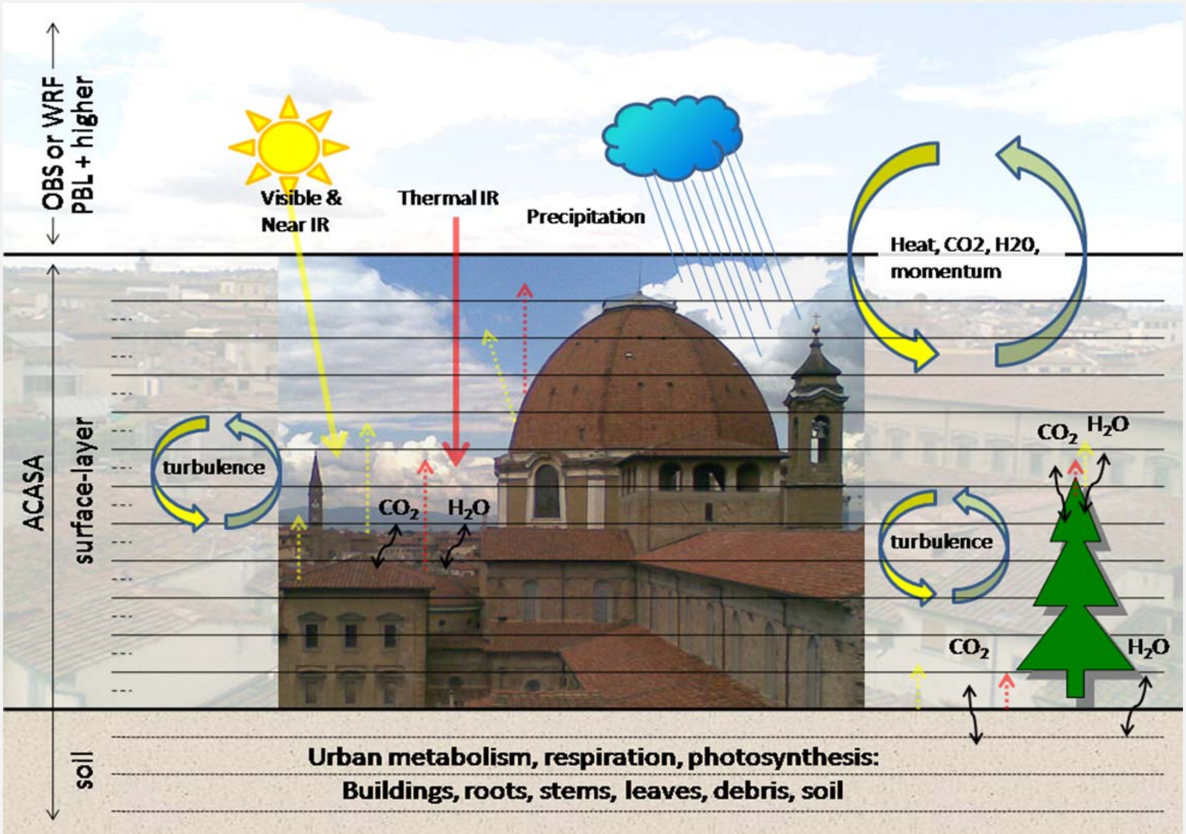

Figure 1. ACASA schematic representation. Soil, surface and atmosphere are considered as a multilayer system.

The model was calibrated and validated using the Eddy Covariance flux measurements continuously collected at the Ximeniano Observatory from fall 2005 by the CNR Institute. Local scale simulations of sensible heat (H), latent heat (LE), and carbon (NEE) fluxes have been produced for the period January-April 2008. In general, simulated fluxes matched the observations well, with only small differences for most of the fluxes. Observed vs. model composite estimates of fluxes were statistically indistinguishable at the 95% confidence level. The coupled model WRF/ACASA was also run for Firenze case study. Results from WRF-ACASA temperatures at the surface and at 2-meters, latent and sensible heat fluxes, at roughly 2-week intervals were obtained, and compared with 'Observations' (reanalysis) and WRF-NOAHLSM (control) for each field. In each simulation, WRF-ACASA was run first on a coarse (48km) horizontal mesh and then at 200m spatial resolution.

The latest results obtained so far are comparable and encouraging, therefore the use of the ACASA model to simulate the urban fluxes is promising and future applications for studies at both local and meso-scale spatial resolution are planned.

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LUMPS: New developments and application to London

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The Local-scale Urban Meteorological Parameterisation Scheme (LUMPS) uses commonly measured meteorological variables and surface characteristics to model the urban surface energy balance at the local scale (10^2 to 5×10^4 m) (Grimmond and Oke 2002; Loridan et al. 2010). The radiation model in LUMPS has recently been improved (Offerle et al.2003; Loridan et al. 2010) and tested in a number of cities (Grimmond et al. 2010a, b; Loridan et al. 2010). The radiation component is also used in the SUEWS model which models the radiation, energy and water balances for an area at the same scale. In both the storage heat flux is modelled using the Objective Hysteresis Model (OHM) (Grimmond et al.1991, Grimmond & Oke 1999).

In this report we will describe the improvements to the radiation model and show some initial results for London from the improved LUMPS.

2. Incoming Long wave radiation flux (L↓)

The radiation sub-model in LUMPS simulates L↓ from cloud fraction estimates. To cope with situations where cloud observations are not available, a new simple parameterization was developed using observed air temperature, relative humidity and cloud cover fraction obtained using a Vaisala CL31 ceilometer in central London (Loridan et al. 2010). The ceilometer is a LiDAR (Light Detection And Ranging) active remote sensing device that utilises the time taken for a laser beam fired at a high repetition frequency to be transmitted to and back from the base of the cloud to the ceilometer receiver. Using data taken over a period of 900s centred on the desired observation period it is possible to calculate cloud cover fraction above the ceilometer.

The new scheme has been evaluated using observations in Łódź, Poland (Offerle et al. 2006) and Baltimore, Maryland, USA (Grimmond et al. 2002). Results show that L↓ model performance is much improved using the new parameterization with a reduction in nocturnal biases in L↓. This parameterization is used if observed data (either by ceilometer, airport cloud data (NCDC 2009) or measured L↓) are not available or applicable to the site.

3. Application to London

The forcing data for the model runs used here for the London Central Activity Zone (CAZ) has been collected over the period October 1 2008 to September 30, 2009 at the KSK site. This site has a tower at King's College London, located within grid 3004 of Figure 1. Geographical data from Virtual London is used to characterize the area overlain by Ordinance Survey Master map. The surface land cover (Figure 1) is divided into the following fractions: building, paved, deciduous trees, coniferous trees, grass (irrigated and un-irrigated) and water. In addition the median heights of the vegetation and buildings are shown.

4. Results for London

The LUMPS model has been run with the spatial variation in surface fractions accounted for, however not all parameters for the complete model runs have been finalised. Figure 2 shows the frequency distribution of net all-wave radiation (Q^*) and latent heat flux (Q_E) for each grid square for the summer months (June, July, August (JJA)) and the winter months (December, January, February (DJF)). As would be expected the distribution of Q^* changes seasonally with a greater proportion of lower values during DJF and a wider range of values observed during JJA. Modelled Q_E values are on the whole small relative to Q^* throughout the year. There is a larger range of values during JJA; especially for grid squares with a large vegetative fraction (e.g. 2921 to 2924 (Figure 1)).

In winter (DJF) values are lower due to a reduction in leaf area index. Figure 3 shows an example of the diurnal radiation balance for grid square 3004 on day of year 286, 2008 which was a clear day, as shown by the smooth curve for Q*.

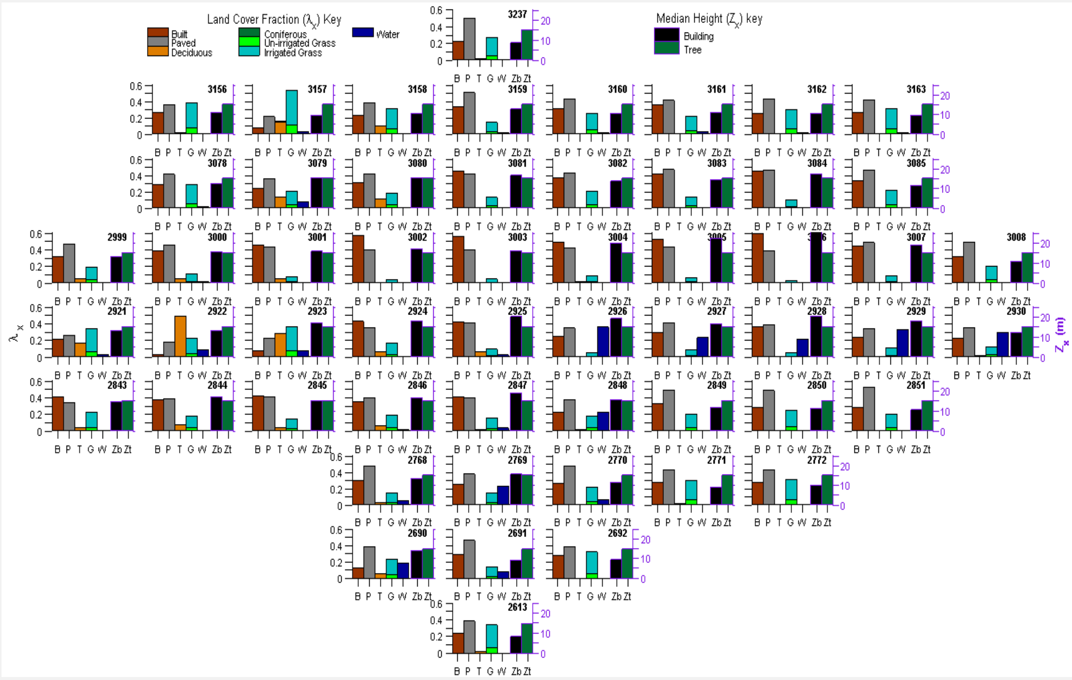

Figure 1: Land surface characteristic for 1 km^2 grids in the Central Activity Zone of London. The area covers 55 km^2.

5. Final comments

The model is currently undergoing intensive testing to evaluate model performance. The LUMPS version currently included in the BRIDGE DSS (Decision Support System) is the Loridan et al. (2010) version. It is planned to also include the new SUEWS version (which also gives the LUMPS output) into the DSS. A manuscript is in preparation which describes the SUEWS model and it's testing (Jarvi and Grimmond plus others).

For the London CAZ we are currently working with Greater London Authority to evaluate where additional trees should and could be planted in London. Results from this evaluation will be combined with work to identify buildings suitable for the planting of green roofs, with both adjusting the surface characteristics within the CAZ. These changes will be used as input for LUMPS (and the new SUEWS version) to model the impacts of on the urban surface radiation, energy and water balances.

Acknowledgements

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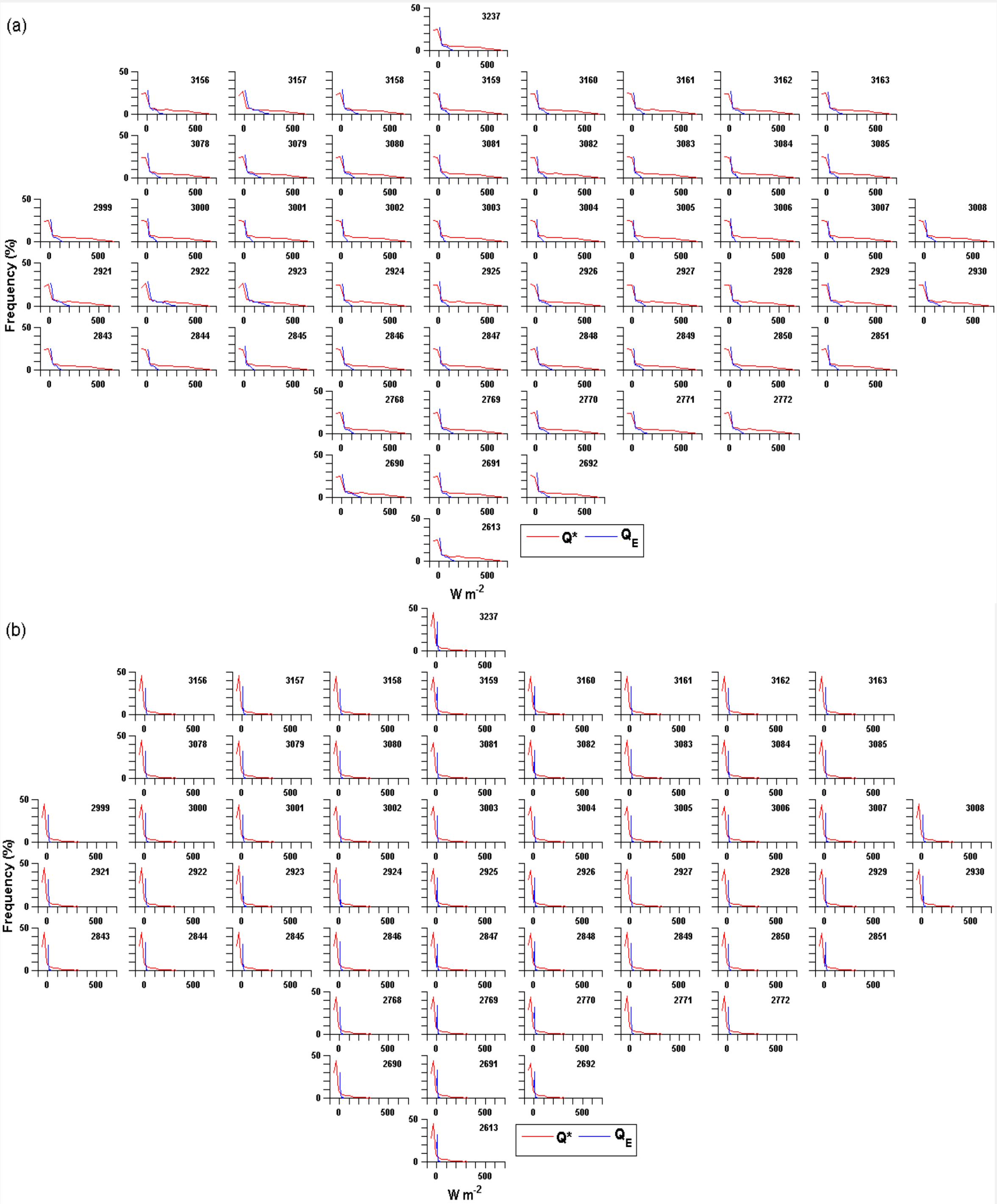

Figure 2: Seasonal percentage frequency distributions of net all-wave radiation (Q*) and latent heat flux (QE) (Units: W m^{-2}) for the Central Activity Zone in London for a) JJA June, July, August and b) DJF December, January, February.

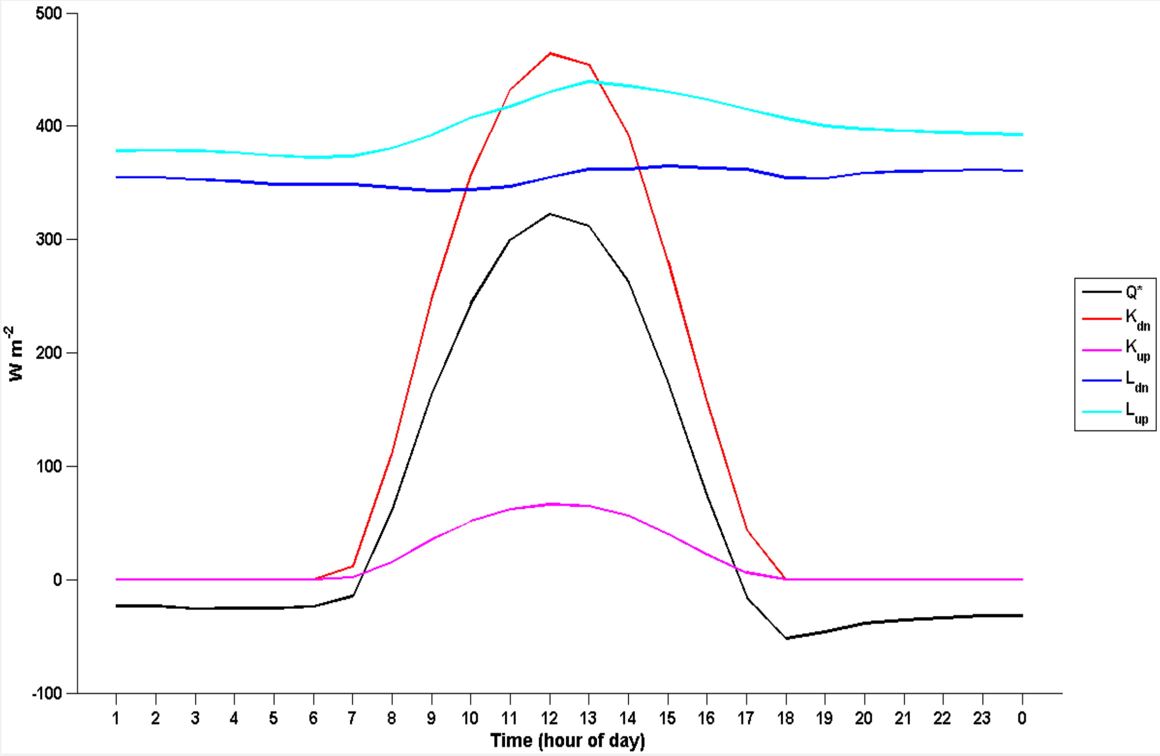

Figure 3: Radiation balance for grid number 3004 on day of year 286, 2008.

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Final Set of Objectives and Indicators for BRIDGE

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Introduction

The sustainability objectives and indicators defined through the various CoP workshops and agreed at the Umbrella CoP form the basis for the assessment of proposed planning alternatives in the Decision Support System (DSS). The main objective of the assessment is to integrate information on physical flows of energy and material with social and economic changes and policy priorities. Based on this integration, planning alternatives are assessed against multiple criteria to establish which of these alternatives presents the most sustainable solution.

Given the different planning priorities and sustainability considerations in each of the case study cities, the selected indicators represent an overall set within the urban metabolism context of BRIDGE. However, the set contains two groups of indicators: those that are common to all the case study cities (core indicators that are presented as defaults in the DSS) and those that address city-specific sustainability issues (discretionary indicators that are presented as optional in the DSS).

Final Set of Indicators

The final set of indicators has been validated against the field measurements and modelling operations being undertaken within BRIDGE. This final set (see environmental and socio-economic indicators in Tables 1 and 2 below) includes spatial, non-spatial, qualitative and quantitative indicators covering the relevant environmental and socio-economic considerations for sustainable urban planning. Planning alternatives will be evaluated based on the performance of individual indicators, but also on the overall performance on the alternative when compared against another. Therefore, indicator values will be normalised and aggregated to obtain a sustainability index that will enable ready comparison between assessed planning interventions.

Table 1. Final set of environmental core and discretionary indicators.

CORE ENVIRONMENTAL INDICATORS	UNITS	TARGET / LIMIT
POLLUTANTS AND CARBON		
Green House Gases: **Carbon dioxide (CO_2) emissions** **Carbon dioxide (CO_2) flux** **Methane (CH_4) emissions**	 Kg/h (or tones/year) Flux: $\mu g/m^2/sec$	*Specific national targets (commonly referred to in % of reference values or as Tones CO_2-equivalent over 5 years)*
Concentrations of toxic substances per hour and concentration limits **Nitrogen dioxide (NO_2)** **Thoracic particle (PM_{10})** **Fine particle ($PM_{2.5}$)** **Ozone (O_3)** **Carbon monoxide (CO)** **Sulphur dioxide (SO_2)**	$\mu g/m^3$	 200 $\mu g/m^3$ per hour 50$\mu g/m^3$ per day *No limit defined yet.* 120 $\mu g/m^3$ per 8 consecutive hours 10000 $\mu g/m^3$ per 8 consec. hours 350 $\mu g/m^3$ per hour
Number of cases where the numeric value for the following pollutants is exceeded **NO_2 limit (200 $\mu g/m^3$ - alert threshold 400 $\mu g/m^3$ in 3consecutive hours)** **PM_{10} limit (50$\mu g/m^3$)** **O_3 limit (120 $\mu g/m^3$ - alert threshold 240 $\mu g/m^3$ in an hour)** **SO_2 limit (350 $\mu g/m^3$)**	days	Non-consecutive: 18 days/year 35 days/year 25 days/year 24 days/year

ENERGY		
Energy consumption in the building sector for air conditioning (cooling/heating in buildings)	KWh/m^2	*Reference value**
Anthropogenic heat flux	W/m^2	*Reference value**
Sensible Heat Flux and Latent heat Flux (Bowen Ratio)	Bowen ratio	*Reference value**
Percentage of energy from renewable energy sources	% (KWh) of total	*Specific national targets (commonly referred to as % of total)*
WATER BALANCE		
Water consumption per capita	m^3/capita/year	*Reference value**
Water consumption (external – e.g. irrigation)	mm^3/year	*Reference value**
Evapotranspiration	mm^3/m^2	*Reference value**
Infiltration (in green surface areas)	mm^3/m^2	*Reference value**
Surface run-off	mm^3/m^2	*Reference value**
Potential flood risk	Peak mm^3/m^2 discharges	0
DISCRETIONARY ENVIRONMENTAL INDICATORS	**UNITS**	**TARGET / LIMIT**
THERMAL COMFORT		
Thermal comfort (CP)	Wind speed (m/s), temperature (°C)	*Specific national thresholds or Reference value**
Air Temperature (outdoors) at 2m above ground	°C	
Number of days above established thresholds	Cumulative °C Days	*Specific national thresholds*
GREEN SPACES		
Number of inhabitants per green area	Inhabitants/m^2 of green area	*Specific national targets or Reference value**
Newly created canopy surface or green area	m^2	*Reference value**
Number of inhabitants with access to green areas	No. of inhabitants *(within 300m)*	*Reference value**
MATERIALS		
Volume of material re-used (recycled)	m^3 of total	*Reference value**

* Reference value: Targets limits are not applicable and, therefore, the alternative will be compared against the do-nothing or reference values.

Table 2. Final set of socio-economic core and discretionary indicators.

CORE SOCIO-ECONOMIC INDICATORS	UNITS	TARGET / LIMIT
LAND USE		
New urbanized areas (land use changes including greenfield and brownfield)	m^2 (or % change)	*Reference value**
Brownfields re-used	m^2 (or % change)	*Specific national targets or Reference value**
Density of development	built m^2/total m^2	*Specific national targets or Reference value**
ECONOMIC VIABILITY		
Cost of proposed development	€ (or €/m^2)	*Reference value**
Effects on local economy (employment)	No. of new jobs created	*Reference value**
Effects on local economy (revenue)	€ (or €/m^2)	*Reference value**

MOBILITY / ACCESSIBILITY		
Quality of pedestrian sidewalks	N/A *(qualitative)*	*Reference value**
Length of cycle-ways provided	m	*Specific national targets or Reference value**
Length of new roads provided	m	*Reference value**
Use of public transport	% of total population using public transport	*Specific national targets or Reference value**
Number of inhabitants with access to public transport	No. of inhabitants *(within 500m of public transport)*	*Reference value**
HUMAN WELL BEING		
Number of inhabitants exposed to NO_2 concentrations above the threshold	No. of inhabitants exposed	*200 µg/m^3 no more than 18 times a year*
Number of inhabitants exposed to PM_{10} concentrations above the threshold	No. of inhabitants exposed	*50 µg/m^3 no more than 35 times a year*
Number of inhabitants exposed to O_3 concentrations above the threshold	No. of inhabitants exposed	*120 µg/m^3 for 8 hours no more than 25 times a year*
DISCRETIONARY SOCIO-ECONOMIC INDICATORS	**UNITS**	**TARGET / LIMIT**
SOCIAL INCLUSION		
Number of inhabitants with access to services	Number of services/m^2 (inhabits/service)	*Reference value**
Number of inhabitants with access to social housing	No. of inhabitants (% of total)	*Reference value**
HUMAN WELL BEING		
Number of inhabitants affected by flash flooding	No. of inhabitants	0
Number of inhabitants affected by heat waves	No. of inhabitants	0

* Reference value: Targets limits are not applicable and, therefore, the alternative will be compared against the do-nothing or reference values.

Spatial-scale Considerations

Although sustainability objectives were set at city level during the initial round of CoP meetings, the final set of indicators was selected based on the planning alternatives defined during the second round of CoP, facilitating detailed measurement and meaningful alternative assessment.

Due to the differing geographical extents and planning hierarchy levels considered in the case studies, spatial scale considerations were carefully addressed by the project team during a technical meeting. It was agreed that, where possible, indicators are to be provided by the DSS in spatial format (i.e. map form) to be able to identify spatial distributions and patterns. This will facilitate the identification of hot-spots or concentration of planning issues (e.g. cumulative impacts). To standardise modelling operations and provide comparable spatial datasets, a geographical extent of 5.4x 5.4 Km has been adopted in BRIDGE – which covers the study area of the planning alternatives for all the cities except for London where the Central Activity Zone has a larger extent. The adopted spatial resolution is 200x200m, which is considered to provide sufficient detail at both strategic and local planning level. Nevertheless, every effort has been made to adopt consistent geographical scales and, in this way, provide comparable model outputs and facilitate their integration in the DSS.

Time-scale Considerations

Time scale considerations have also been addressed, as far as practicable, in the BRIDGE project. Due to data availability constrains, the DSS prototype will be run with 2008 datasets and will, therefore, assess planning alternatives against the baseline environment for that year. When comparing planning alternatives, the DSS will produce annual mean values for the different indicators (which will also entail a mean spatial value for the study area). This will facilitate strategic comparison of assessment outcomes.

Several indicators (particularly those associated with air quality) have very specific time scales set in the relevant EU or national legislation (e.g. a concentration of 50 $\mu g/m^3$ of PM_{10} cannot exceeded more than 35 times a calendar year). Therefore, to address temporal variation and determine whether a given planning alternative fulfils legislative requirements, the end-user will also be able to retrieve indicator values on an hourly basis, to examine trends and daily/seasonal variations. In all cases, the provision of an absolute annual value is essential to enable the aggregation of indicators and calculate the performance index of each planning alternative.

Modelling Considerations

Modelling capabilities within BRIDGE have not limited indicator selection as such, but a clear differentiation has been made between those indicators that can be modelled within the project and those for which values need to be provided by the end-user. In this way, a subset of the sustainability indicators (i.e. those associated with air pollutants, water balance and energy fluxes) is automatically calculated by online and offline models and displayed in the DSS, while the end-user is prompted to input the value of the rest of the indicators (e.g. socio-economic).

Time and resources, as well as lack on data in some instances, affect the implementation of modelling tools. Therefore, not all models available are applied to all the case study cities and not all the case study cities are subject to the same modelling operations, with associated effects on indicator calculation (Table 3). To optimise their application, models have been incorporated online into the DSS, but several models have remained offline due to their high computer demand. In this case, the outputs of offline models are automatically integrated into the DSS so the end-user has ready access to them.

Table 3. The application of BRIDGE models to the case study cities.

MODELS		OUTPUTS	CASE STUDIES				
			Athens	Firenze	Gliwice	Helsinki	London
ONLINE	URBAIR	air pollutants concentrations	X	X	X	X	X
	LUMPS	water and energy balance					X
	SIMGRO	water and energy balance				X (Water)	
	SURFEX	energy balance + energy consumption, water balance	X			X (Energy)	
OFFLINE	WRF/UCM	meteo + energy and water balance	X	X	X	X	X
	WRF/CHEM	Pollutants concentrations	X	X	X	X	X
	CMAQ	Pollutants concentrations	X	X			
	MM5/CAMx	Pollutants concentrations			X	X	X
	WRF/ACASA	energy and water balance + CO2 fluxes		X			

Deliverables

1. Project Management Plan, D.1.1.

2. 1st Quarterly Progress Report, D.1.2.1.

3. 2nd Quarterly Progress Report, D.1.2.2.

4. 3rd Quarterly Progress Report, D.1.2.3.

5. 4th Quarterly Progress Report, D.1.2.4.

6. 5th Quarterly Progress Report, D.1.2.5.

7. 6th Quarterly Progress Report, D.1.2.6.

8. 7th Quarterly Progress Report, D.1.2.7.

9. BRIDGE Web-Site, D.9.2 (operational).

10. Dissemination and Use Plan, D.9.1.

11. Inventory of current state of empirical and modelling knowledge of energy, water and carbon sinks, sources and fluxes, D.2.1.

12. Protocol to assess differences between knowledge supply and knowledge needs in the field, D.2.2.

13. Protocol to Develop Communities of Practice in the Context of the BRIDGE Project, D.2.3.

14. Datasets of air quality, energy, water, carbon and pollutants fluxes/concentrations, D.3.1.1.

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Deliverables (…continued)

15. GIS data and maps of energy and water fluxes, pollution concentrations, land cover and vegetation, D.3.2.1.

16. GIS data and maps on spatial, socio-economic development and impact indicators, D.3.3.1.

17. Model Selection Report, D.4.1.

18. DSS Design Report, D.6.1.

19. Socio-economic-environmental workshops Report, D.5.1.

20. Mid-term Report, D.1.3.

21. Datasets of air quality, energy, water, carbon and pollutants fluxes/concentrations (1st update), D.3.1.2.

22. GIS data and maps of energy and water fluxes, pollution concentrations, land cover and vegetation (1st update), D.3.2.2.

23. GIS data and maps on spatial, socio-economic development and impact indicators (1st update), D.3.3.2.

24. Report on the impacts assessment model for urban metabolism, D.5.2.

25. Indicators definition report, D.5.3.

26. BRIDGE Published Material, D.9.3.i (see Publications section).

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