Natural Ventilation Performance in a High Density Urban Area Based on CFD Numerical Simulations in Dalian

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The urban expansion of Dalian city over the past 60 years from approximately 50 sq. km to 500 sq. km has been characterized by a high-density downtown morphological pattern, while the urban wind speed per year has trended downward. To evaluate natural ventilation performance in the high-density downtown area of Dalian, an in situ wind environmental survey was performed, and the results were used as a reference to configure CFD numerical simulation boundary conditions. The results indicate that urban edifices, such as enclosed city blocks, strip apartments in rows and, especially, high-rise buildings with large podium bulk, were unfavorable to natural ventilation and could reduce the mean wind speed by up to 78% relative to the approaching speed. The natural ventilation performance of different building morphologies were further evaluated via CFD simulations, which indicated such strategies as using ventilation paths, hybrid buildings with different heights, building stilts, and increasing building height while decreasing their land coverage could improve the urban ventilation performance. Increasing the building height and reducing land coverage was one of the most efficient strategies and increased wind velocities up to 2.4 times the real case. Green land significantly cooled and humidified its surroundings, particularly the downwind spaces. The corresponding morphology optimization measures were been discussed.

Study on the Applicability of Urban Spatial Morphology Indicators for Block Ventilation Research

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Studies are still required to understand the relationship between the wind situation and the block form, which can be seen as an important factor for urban planning. Yet prior to this kind of study, selecting an urban spatial morphology indicator system that could not only describe the change of block form precisely but also have a good relativity with the changing mean wind speed aroused by the former, which is a reasonable breakthrough point for exploring the relationship between the block form and the wind environment, is necessary. Consequently, this paper intends to find a series of proper urban spatial morphology indicator systems, and then, to discuss the applicability of them for block ventilation research.Through extensive literature survey, 7 groups of urban spatial morphology indicator systems are selected, such as plan area density, frontal area density, packing density, sky-view factor or rugosity and so on. And next, the method of CFD is introduced to quantitatively analyze the link between the wind condition and the changing block form. Finally, we establish the relationship between urban spatial morphology indicator systems and the wind condition to select the proper indicator system for block ventilation research, and put forward a new concept called “effective rugosity” as an indicator to evaluate wind flow.

Anthropogenic heat contribution to air temperature increase at pedestrian height in Singapore's high density Central Business District (CBD)

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Half of the world's population today live in cities, causing intensification of urban developments (UN, 2008) created from man-made materials that generate and retain heat. This creates an urban climate which is hotter than its surroundings, generally known as the Urban Heat Island (UHI) effect. Human beings are anthropogenic heat sources which contribute to this increased thermal pollution in cities via human metabolism, buildings and vehicles (Sailor and Lu, 2004) apart from the sun and sky which form the natural sources under the Urban Energy Balance inputs (Oke, 1987). In dense cities like Singapore, motor vehicles ownership is double the amount of Hong Kong with almost identical population density as well as built density based on the Height-to-Width (H/W) Ratio. It measures how close buildings are built to each other. It normally increases with the temperature difference between the urban and rural areas (Roth, 2013) and when population in cities increase (Oke, 1973).

The research is into the contribution of anthropogenic heat at pedestrian level in the densest part of Singapore, which is located in the Central Business District (CBD) at microscale to local scale to air temperature increase. This is classified as Local Climate Zone 1 which is compact high rise (Stewart and Oke, 2012). An anthropogenic heat inventory method study was done in Singapore (Quah and Roth, 2012) which shows that the commercial area has bigger contribution that high rise apartments and landed housing with more contribution during weekdays during office hours. The buildings contribute the most, followed by vehicles and human metabolism. However, at pedestrian level, substantial contribution from the vehicles is expected since most heat waste from commercial buildings are released at the podiums or rooftops.

Computational Fluid Dynamics (CFD) is used to study various aspects of the urban environments for the last 50 years (Blocken, 2014). It has the advantage over the energy balance model as it does not decouple temperature and wind flow (Toparlar, et al., 2014). Urban canyon studies are done to understand flow behavior and more recently on the surface convective heat transfer aspect (Magnusson et al., 2014). In terms of contribution from the climate sources, (Bottillo et al., 2014; Nazarian and Kleissl, 2014; Toparlar et al., 2014) have studied it but at lower H/W Ratios of up to 2. Contributions from buildings alone are studied by Huang et al., 2005; Priyadarsini and Wong, 2009; Hashimoto et al., 2014 while Chen et al., 2009 studied it together with vehicles contribution. Chen et al, 2009 showed that the impact from the traffic is the highest at the pedestrian level regardless of whether it is a high rise or low rise district.

A roadside measurement at 1.5m height was done near a bus stop in a deep canyon in the CBD area during the afternoons of the dry month of February 2014. The measurement showed a maximum air temperature difference of 4.5°C during the peak hour between absence and presence of buses with higher temperatures recorded during weekdays.

A 6am-6pm slab and points street canyon of H/W ratio of 2 and 4 with as well as without double decker buses were simulated in the transient CFD environment with perpendicular and parallel flow. The solar radiation was activated with gravity enabled. Measurements at the pedestrian height at the pavements show air temperature increase of close to 3°C between cases with and without buses. Cases with parallel flow regulates air temperature inside the canyon better than perpendicular flow. Higher H/W ratio cases generate better channeling effect for parallel flows while retaining higher air temperature for perpendicular flow because of bigger heat storage.

In conclusion, results show that form and density make the difference for flow and heat transfer in the canyon. For future studies, parametric studies will be done for the worst case scenario where the road is filled with vehicles, mimicking the peak hour and the impact of various urban morphologies.

Urban wind design for Bonifacio's citadel

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The citadel of Bonifacio is located at the extreme south of Corsica. That small maritime city was built on a peninsula, up to 50 meters above the sea, to protect the commercial route crossing by the strait of Bonifacio between Corsica and Sardegna. By 1996, the army abandoned the city, leaving 30.000 square meters of land and buildings to transform.

The project deals with the needs of the old city, transportation concerns, economical and tourism development, and environmental concern. Around 2 millions tourists visit Bonifacio each summer, and the city would like to welcome visitors all seasons long. The project comprises a museum, a new luxurious hotel, a big parking and some public facilities.

But, even for summer journeys, if you stay in Bonifacio you will run the risk of strong wind events. Indeed, Bonifacio is the windiest city of Mediterranean area, and one of the windiest in the world. A strong wind is blowing up to 155 days a year, and up to 100 km/h for 20 days amongst it.

To ensure pedestrian safety and comfort for the new streets and public spaces of the citadel, we developed an urban design process, combining Computational Fluid Dynamics (CFD) models and wind tunnel testing with PIV measurements. As a result, the design for the new district organises protected areas with a concept of protection belts. The concept uses new buildings and old ones, gardens with progressive heights of trees, to reduce wind speed and turbulent flow.

In the past, the citadel ensured protection for the army to control the strait. Today, the citadel is open and welcomes tourists to visit a place now dedicated to the environmental protection of the strait.

Air Quality in the City of Erzurum: Strategies for Climate Sensitive Urban Design

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In this paper, it is claimed that the relationship between urban design and climate conditions enable the emergence of sustainable urban physical environments that will be the places of the world of the future. After serious ecological problems like urban heat island and urban air pollution in this century, researchers began to focus on bioclimatic- and eco-comfort in urban areas. Air circulation or ventilation channels as one the climate and comfort related variables is essential for the mitigation of air pollution, heat temperature, cooling and ventilation.

The main objective of this paper is to explore the relationship between the wind flow, air pollution and physical structure of the built environment in the city of Erzurum, Turkey. It attempts to understand the reasons of the environmental problems and propose climate sensitive urban design approaches by emphasizing green air corridors or wind channels for Erzurum. In this study, it is questioned whether the urban form and geometry (size, density, street orientation and ventilation), street and public space layout, height and shape of the buildings, vegetation, energy flow and water cycle in selected corridors of Erzurum are designed according to the prevailing wind direction and climate conditions. In this direction, by considering the general features of the ventilation channels, orientation and continuity of open spaces, streets and parks, dimensions and shape of open spaces, construction practices, settlement patterns, housing typology, density, building topography, average height, hard-surfaces, distances, property relations, flora and density of green areas are analyzed for the axles extending parallel to the wind direction towards agglomeration areas of air pollution in the city.

The findings show that urban built environment in the Erzurum prevent the ventilation. Existing air pollution, ventilation problems and high temperature differences in the city are the threatening factors for ecologically sustainable urban development. Settlement pattern and urban form of the selected corridors or axles must be reconsidered with ventilation perspective. Creation of green ecological spaces in old areas, new green public spaces, and reasonable range of building density can be accepted as the first stage solutions for the city. Otherwise, central areas of the city and its urbanization process will again be unsustainable in the future and have low quality of life. For ecologically sustainable urban development, climate sensitive urban design approaches and ventilation channels must be developed and designed for Erzurum.

Keywords: Climate, Air Pollution, Ventilation, Built Environment, Urban Design

Preserving Overall Performance of Air Conditioners by Incorporation of Wind- Permeable Floor in Buildings.

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Hong Kong is a highly urbanized city with high population density, therefore extensive mechanical ventilations are required to provide space cooling and thermal comfort for occupants during hot and humid summer seasons. Unitary air conditioners are ubiquitously installed at the re-entrants of buildings, operating continuously and concurrently, generating a vast amount of heat. Residual heat ejected by outdoor condensing units is accumulated within semi-enclosed re-entrants of buildings, degrading the energy conversion efficiency of air conditioners due to high working temperature. Wind advection and thermal buoyancy mainly drive the motion of hot air stream, imposing vertical temperature gradients at the re-entrants. Literatures have reported that temperature difference between rooftop and ground level of a typical 30 storey building could reach 7˚C; moreover, overall percentage drop in coefficient of performance of air conditioners could reach a maximum of 26% under no-wind condition. In this study, effectiveness of incorporating an open wind-permeable floor, attempting to alleviate thermal stack effect and preserve energy conservation of buildings, is investigated. A typical residential block with a wind-permeable floor at mid-level is compared with the same residential block without one. Temperature profiles and group performance of the air conditioners, indicated by Condenser Group Performance Index, are evaluated for the subjected buildings by steady Reynolds Averaged Navier Stokes simulations under both wind driven and buoyancy driven conditions. After the implementation of an open permeable floor in the residential blocks, elevated air passing through the floor is cooled by natural means. Performance of air conditioners are retained as a result of lower operating temperature, especially for those installed above the wind-permeable floor.

Urban canyons morphology, thermal comfort and urban design in concepcion's city, chile.

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This study is part of understanding the urban microclimate at scale of the urban canyon and its relationship with thermal comfort and urban design. It were selected 9 urban canyons located in the metropolitan center of the city of Concepcion, Chile. For morphology analysis, Local Climate Zone classification system (Stewart and Oke, 2009) was applied. Fish eye photographs (sky view factor), height of buildings using LIDAR data, air temperature and wind speed obtained from field measurements, and solar radiation data and shadowing by Ecotect software, were studied. All these inputs are integrated in the Actual Sensation Vote (ASV) thermal comfort index (Nikolopoulou et al. 2004).These results were compared with thermal comfort survey passers, and then were interpreted considering urban design factors that have a significant impact on the thermal comfort of the public space during the summer.

Finally it is noted that as there are covered canyons, corresponding to "Tulipas" project, having higher degree of discomfort. On the other hand, the canyon of the diagonal street Pedro Aguirre Cerda regarding the urban net due to its characteristics of orientation and morphology is the one with the best rates of thermal comfort in relation to the physical aspects. While generally the metropolitan center of Concepcion is a comfortable place in summer it is expected that the future effects of climate change shift this condition. It is concluded that urban regulatory plans play a relevant role in adaptation measures.

Keywords: ActualSensation Vote, GIS, Sky View Factor, Climate adaptation.

The impact of urban geometry on the radiant environment in outdoor spaces

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Urban geometry, namely the quantitative relationship of building volumes and open spaces (i.e. built density) and their spatial configuration (i.e. urban layout), is a major modifier of urban microclimate. This paper presents the results of an ongoing research which explores the impact of urban geometry on the radiant environment in outdoor spaces, with direct implications for urban microclimate and outdoor thermal comfort. In particular, the research investigates the relationship between a set of urban geometric indicators (such as Built Density, Site Coverage, Mean building Height and Frontal Area Density) and Mean Radiant Temperature (Tmrt) at the pedestrian level, in different areas of London.

Three representative areas of London were selected to be studied; in central, west and north London which are of high, medium and low built density, respectively. Each area was divided into squares of 500m x 500m size, with a total of 84 urban squares included in the study. The methodology comprises three stages: (i) A set of simple geometric indicators have been computed for all urban squares using special algorithms written and executed in Matlab software. (ii) Radiation simulations have been performed for 10 days of a typical year in London, with the use of SOLWEIG software. SOLWEIG simulates hourly, 3-D radiation fluxes, incoming to / outgoing from the ground, spatial variations of Tmrt, Ground View Factor (GVF) as well as Sky View Factor (SVF). Sunny and cloudy days have been considered, evenly distributed in the year in order for the effect of solar angles to be examined. (iii) Statistical tests have been conducted for investigating the correlation between urban geometry, as expressed by the geometric variables, and hourly, average values of Mean Radiant Temperature in the outdoor spaces of the urban squares.

The simulation results show that at night-time and in fully overcast conditions, the outdoor spaces of central London's urban squares are warmer than those of west and north London, due to greater longwave radiation emitted and reflected by building volumes. In contrast, on sunny days, average daytime Tmrt values have been found to be higher in North London's urban squares due to the larger insolation of their outdoor spaces. Additionally, the statistical analysis has shown that in the absence of direct solar radiation, the correlation between the geometrical variables and average values of Tmrt is very high with an almost perfect linear relationship between the geometrical variables and average SVF values ($r2= 0.980$). In the presence of direct solar radiation, the strength of the correlation varies with the sun altitude angle; the higher the sun altitude angle, the higher the correlation. In particular, a threshold altitude angle of 20 degrees has been identified, above which the correlation of average Tmrt values with urban geometry approximates that of night-time / cloudy hours. Finally, further statistical tests showed that site coverage (built area over site area) and frontal area density (façades' total area over site area) are the strongest indicators among those considered in the analysis.

Neighbourhood morphology and solar irradiance in relation to urban climate

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Assessing the relationship between neighbourhood morphology and urban climate is becoming increasingly important as cities continue to grow and the climate continues to change. Here we focus on the impact of (1) shapes and sizes of buildings, (2) street layouts, and (3) spatial distributions of buildings and streets on the urban climate in the 16 neighbourhoods (zones) within the city of Geneva, Switzerland. The results show that the size distributions of the areas, perimeters, and volumes of the buildings follow approximately power laws, whereas the heights of the buildings follow a bimodal (two-peak) distribution. Using the Gibbs-Shannon entropy formula as a measure of dispersion (spreading), we calculate the area, perimeter, volume, and height entropies for the 16 neighbourhoods in Geneva and show that the entropies have strong positive correlations (R^2 = 0.43-0.84) with the average values of these parameters. By contrast, there are negative correlations (R^2 = 0.39-0.54) between building density or urban compactness (site coverage and volume-area ratio) and the entropies of building areas, perimeters, and volumes. The calculated length-size distributions of the streets show negative correlations (R^2 = 0.70-0.76) with the number of streets per unit area as well as with the total street length per unit area. We compare the neighborhood morphologies with the annual and monthly solar irradiance for each of the 16 neighborhoods using the simulation tool CitySim. The results show a negative correlation between building densities and solar irradiation as well as between street densities and solar irradiation. By contrast there is a positive correlation between entropy of the street lengths and solar irradiation, indicating that the greater the variation in street length the greater the solar irradiation. Further work will include comparison of these results with the average surface temperatures, sky view factors, and daylight factors in the 16 neighborhoods so as to explore the relations between neighborhood morphology and the local climate and, thereby, providing quantitative information to help urban designers in the decision making processes.

Climate-Conscious Development of an Urban Area

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Climate-conscious urban planning, especially that of public spaces, has little history in Hungary. Although Hungary's Environmental Law requires that each settlement prepare a program for the protection of the environment, these documents tend to be either overly theoretical studies or summaries of the initiatives of local non-governmental organisations. In urban planning documents, climate consciousness manifests itself mostly in the parroting of well-known slogans, without any concrete practical suggestions.

Relying on several years' worth of research identifying and evaluating factors that influence climate, and inviting the contribution of external partners, we tested the effects that climate-related factors of urban development had on a pilot area. Background support for the experiment was provided by a computer program called ENVI-met, which, based on knowledge of the existing situation, is able to use several dozen climatic variables to calculate changes that would occur if the plans were realised.

The methods applied here are not new to public space planning: it is well known both in and outside professional circles that vegetation, for example, cools the environment through evapotranspiration; and these methods represent the primary tools employed in the redevelopment of outdoor public spaces in general.

Within the pilot area, the planners of the Budapest modelling regions used the following tools provided by the climate specialists of UHI:

Single Alleys, Double Alleys, Planters, Green Spaces, Permeable Pavement, Green Walls, Vertical Gardens and Green Roofs.

According to results of ENVI-met simulations it can be stated that within the modelled regions the microclimate – following the localised nature of the intervention – improves in discrete areas due to the proportionate increase of green spaces: cross-ventilation improves, relative humidity increases, mean radiant temperature (MRT) significantly decreases and, in cases of drastic intervention, air temperatures also show significant decreases.

Numerical analysis of heat environment in central Tokyo using tree-crown-resolving large-eddy simulation considering three-dimensional radiation process

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Increase of urban green spaces is considered to be one of the countermeasures to mitigate the urban temperature increase since the “cool spot” effect of green spaces was observed by a lot of field measurements. For the effective planning of urban green spaces, it is important to understand the mechanism of the cool spot effect and its effect on the heat attack risk reduction. This study aims to investigate the influence of trees on the urban heat environment by using the "MultiScale Simulator for the Geoenvironment" (MSSG), which is capable of running as a building-resolving large-eddy simulation model considering the three-dimensional radiation process. The tree-crown-resolving heat exchange model implemented in the MSSG solves the heat balance equation on the tree leaves considering the transpiration, sensible heat and the three-dimensional radiation at each time step and each grid cell inside the tree crowns. The performance of the model is confirmed by conducting simulations for an ideal green space case, whose results show that the model can predict the leaf temperature and heat flux distributions inside the tree crowns. The model is then applied to the case of an actual urban area in Tokyo with the New National Stadium Japan, which will be constructed for the 2020 Tokyo Olympics. The computational domain covers 5km x 5km horizontal area, which is discretized by 5m grid mesh. The initial and boundary conditions for the wind, temperature, humidity, etc. are set based on the reanalysis data at noon on a summer-time clear-sky day, on which a typical meteorological condition of the heat island was observed around Tokyo. The results show that the air temperature around the stadium decreases by increasing trees in the stadium premises. The discomfort index and Wet-Bulb Globe Temperature (WBGT) index are estimated directly from the air temperature, water vapor density and radiation flux data. We will show the estimated results of the indexes and discuss the heat environment mitigation effect of greening.

Sensitivity of Perceived Temperature on meteorological variables and urban morphology parameters

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The Perceived Temperature (PT) is a measure for outdoor human thermal comfort developed by the German Meteorological Service. We investigate the sensitivities of PT on meteorological variables and urban morphology parameters. The meteorological input data is taken from simulation results of the mesoscale atmospheric model METRAS for a domain covering the greater city of Hamburg in northern Germany and a selection of typical synoptic situations during the summer season. The influence of the buildings on the shortwave and longwave radiation is calculated by the radiation modification routines of the Building Effect Parameterisation (BEP) which provide the grid cell-averaged radiation fields within typical street canyons. The sensitivities of PT are determined by automatic differentiation. The sensitivities show how accurate the different input variables need to be known in order to obtain a certain desired accuracy in PT and how PT can be influenced most efficiently (e.g. through adaptation measures). The sensitivities of PT on air temperature, water vapour pressure and mean radiant temperature are higher during warm and humid conditions than in situations with thermal comfort. The sensitivity of PT on wind speed is highest for low wind speeds. Around noon, in street canyons with aspect ratios above 0.5, increasing the building heights by 5 m can reduce PT by down to 2.4 K due to shading effects. After sunset, increasing the building heights by 5 m tends to moderately increase PT by 0 to 0.4 K due to the increased longwave radiation. Future work should focus on a separation between the sensitivities at positions exposed to the sun and positions in the shadow. Further, the indoor thermal comfort should be investigated.

Evaluation of the effect of densification of the built environment on outdoor thermal comfort in warm-humid Dar es Salaam, Tanzania

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Many cities in the tropics suffer from increasingly higher temperatures due to both global and urban warming. Often the thermal conditions are worsened by poor urban design including lack of shade and poor ventilation. Moreover urban regulations are often poorly adapted to the climate and there is often a lack of vegetation. In Dar es Salaam, Tanzania – which has one of the highest urbanization rates in the world mainly occurring as horizontal growth – the thermal conditions are poor, especially in the afternoon during the period October to April (Ndetto and Matzarakis, 2013). In response to this, the urban planning authorities act to densify the city, especially the central areas. This is done through redevelopment schemes which allow considerably higher buildings than previous regulations. The main aim of this paper is to evaluate the effect of the proposed densification of the built environment on microclimate – especially wind speed, solar exposure and shade – and outdoor thermal comfort. The aim is also to suggest how the proposed redevelopment schemes could be modified in order to improve thermal comfort. The study is mainly based on numerical simulations of the influence of parameters such as building form, materials, shading devices and vegetation using the model ENVI-met. This study will provide recommendations to urban planners and designers in Dar es Salaam on how to design thermally comfortable, high-density urban areas. Recommendations will include advice on street orientation, height-to-width ratios of urban canyons, building forms, type and positioning of vegetation and type of surface materials.

The role of urban design in enhancing the microclimate and thermal comfort in warm-humid Dar es Salaam, Tanzania

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Due to the complexity of outdoor environment, urban design patterns considerably affect the microclimate and outdoor thermal comfort in a given urban morphology. Parameters such as building heights and orientations, spaces between buildings, plot coverage, etc influence the microclimate in terms of solar access, shade, wind speed and direction. In warm-humid Dar es Salaam, the consideration of microclimate and outdoor thermal comfort in urban design has received little attention although the urban planning authorities try to develop the quality of planning and design. The main aim of this study is to investigate the relationship between urban design, urban microclimate and outdoor comfort in four different areas in the city of Dar es Salaam, during the wet and dry seasons. This investigation is mainly based on microclimate simulations using ENVI-met and different existing urban morphologies are climatically and thermally studied including low, medium and high rise buildings. Parameters such as Mean Radiant Temperature (MRT), wind speed and Physiological Equivalent Temperature index (PET) are presented as thermal maps to highlight the strengths and weaknesses of the existing urban design in the city. The study illustrates that the areas with low-rise buildings lead to higher MRT values than the areas with high-rise buildings. The results also show that the use of dense trees helps to enhance the thermal conditions, but it might negatively affect the wind ventilation in the outdoor spaces. This study provides a set of guidelines on how to develop the existing situation from microclimate and thermal comfort perspectives. Such guidelines will help architects and urban designers to increase the quality of outdoor environment and demonstrate the need to create better urban spaces in harmony with microclimate and thermal comfort.

Among winds, water bodies and urban elements

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This study analyses the interaction influence of winds and water bodies in the thermal conditions on an unoccupied margins of an urban area. Two temperature and humidity sensors were placed on the two opposite margin of a water reservoir in São Jose Do Rio Preto, Brazil. One, placed on the east margin, and another one on the west margin, to register the differences in between temperature and humidity according to the changes of wind speed and direction. The dates were collected on site in August 2011, compared with dates of a Meteorological Station from CIIAGRO and with Satellite images of CPTEC. After the site monitoring, three different urban occupation models were prepared with the software Envi-met 3.1 in each margin of the water reservoir. So, the created urban scenarios were made to demonstrate how to optimize the natural resources in refreshing the area and to distribute the humidified ventilation through urban space. During the warmest and driest period, the maximum difference of temperature was 1,77°C. It was verified that the wind and water combination kept the east margin average 0,5°C colder and 0,4 g/m³ more humid than the west one. The microclimate urban maps produced by the simulation process could help to predict the better solution of urban design and also indicated the behavior of urban temperature, humidity and winds, presenting the results graphically over the urban area. This study, firstly, indicated that water bodies may increase the stability of the temperature in the nearest in different urban settings. Secondly, the Envi-met 3.1 software demonstrated to be an able tool to estimate quite precisely the effects in the microclimate of possible urban interventions. Thus, water bodies influence their surroundings and indicate to the planners how the effects of environmental resources can produce more pleasant cities.

Climate-Friendly Urban Design Process in Old Towns alongside the Persian Gulf, Case Study: Bushehr

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The northern side of Persian Gulf with hot and humid climate has a rich treasure urban development during history. Bushehr is one of big cities in the region that a context for learning traditional urban design according to climate consideration. Especially in Bushehr old town a hierarchy of climatic design can be seen from site selection to building details.

During these two decades, urban design projects have been started in the old town to provide a better context for urban life. In most of these projects, climate consideration of urban development has not been emphasized as a key factor. So, climatic function of urban spaces in the old town has changed and climatic comfort has decreased in urban spaces.

This research tries to introduce a climate friendly process for urban design projects in Bushehr old town. Thus, as a first step traditional climatic design principals in the old town has been discovered and analyzed base on scientific literature review. Then, main urban design projects have been evaluated based on climatic consideration. Finally, a climatic friendly process has been suggested to enhance the environmental quality of the old town in urban regeneration projects.

Research findings demonstrate that street directions, H/W ratio of streets, street profiles, form of urban plazas, network of urban spaces, building facade designs, architectural spaces design and architectural details in the old completely planned according to climate situation. Especially to have maximum wind in urban and architectural spaces some initiatives can be seen like site selection of city as a peninsula according to local and regional winds, special form of sky line to disturb regional wind, special form of urban spaces, tall building alongside urban spaces higher than other building, direction of main streets to conduct wind into city, section of alleys to absorb maximum wind and some specific architectural elements and space like Shenashir, Tarmeh and Boun.

Three urban design projects have been selected in different type and different part of old town for evaluation. First project is a street from coastline to a neighborhood center. Second is a plaza and third is a pedestrian street at the edge of old town and new urban development part. The attention to wind ,shadow and thermal comfort in this spaces have been analyzed. Final evaluation show less attention to climatic design consideration in planning, design and implementation.

So, based on these results and different models of urban design process, a unique climate-friendly urban design process has suggested for urban design projects in old town of Bushehr.

Keywords: Bushehr, Urban Design, climate-friendly process, design principals

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Application of airborne LiDAR and thermal Infrared technologies for the assessment of human biometeorological conditions in urban areas

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The rising global temperature contributes to a strong impact on urban thermal environment and outdoor thermal comfort. Although the existing satellite telemetry methods are convenient to display geographical information. The detail distributions of 3-dimentional radiation properties of the complex urban environment cannot be estimated accurately due to the low resolution and lack of vertical information. Hence, satellite telemetry methods cannot provide enough information concerning biometeorology conditions in urban areas.

This research applies an innovative method to observe urban thermal environment by coupled airborne LiDAR and thermal Infrared (TIR) technique combined with synchronous climate measurement in ground level. Banqiao District of New Taipei City, one of the highest developed areas in Taiwan, is selected for the survey area. Regarding the airborne survey, the use of high-resolution LiDAR, with 1m*1m resolution, could be imaging from scanning terrain and surface obstacle exploration. Building height, total floor area, vegetation forms and height can be also identified. For the TIR, with 0.5m*0.5m resolution and 0.1°C accuracy, the surface temperature and emitted radiation from horizontal and vertical surfaces can be also estimated. In the screen level measurement, air temperature, vapor pressure, surface temperature, wind speed and direction are all measured simultaneously in the streets and open spaces in survey areas. By combining those three kinds of information through GPS positioning system, the mean radiant temperature (Tmrt) estimated by various approaches can be calculated and compared.

The results indicated that Tmrt estimated by the LiDAR and TIR are highly in accordance with the value measured in the ground level. Furthermore, the Tmrt and Physiologically Equivalent Temperature (PET) are calculated and displayed as a distribution map. The hotspot of the survey area, which comprised high density building and high amount of anthropogenic heat, can be identified through the map. The analytical result reveal that the use of coupled LiDAR and TIR technology approach will be contributed to understand the urban human biometeorological conditions quickly and accurately.

An evaluation of the effects of heat ray retro-reflective film on the outdoor thermal environment using a radiant analysis method considering directional reflection

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It has recently been noted that the adoption of low-e double glazing and heat shading films for windows has a negative impact on the thermal comfort of pedestrians, since these windows usually reflect solar radiation to pedestrian spaces. As a countermeasure to this problem, it is expected that the application of a heat ray retro-reflective film onto window surfaces will have positive impacts by both reducing the indoor cooling load and mitigating effects on the thermal environment in outdoor spaces. This paper describes an evaluation of the effects of a heat ray retro-reflective film applied to a window on the thermal environment of an outdoor space, using a computational method proposed by the present authors. In the former part of this paper, we outline the radiant computational method considering the effects of the directional reflectivity of surfaces. We incorporate these effects into the existing method by extending the computational method proposed by Ichinose et al. (2005) to the evaluation of the outdoor radiant environment. In the latter part of this paper, we investigate the radiant thermal environment around a building during the summer season, using the revised method. Three different windows installed in the building surface are compared: (1) single float glass with a heat ray retro-reflective film, (2) untreated single float glass, and (3) low-e double glass. By comparing the calculation results, it was clarified that the adoption of the heat ray retro-reflective film to the building surface improves the radiant environment for pedestrians during the summer season.

Effects of Different Floor Covering Materials on Thermal Comfort in Landscape Design Studies

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In the context of this study, effects of six different floor covering materials (grass, travertine, empenyel wood, andesite, soil and asphalt) on thermal comfort are determined. Three different landscape design projects covering 500square meters with different floor materials are analysed for thermal comfort. During July in cloudless days, PET (Physiologicall Equivalent Temperature) values were measured by using RayMan Pro2 program with surface temperatures, air temperature, wind and humidity data obtained at 12:00. The findings show that according to PET values (grass: 25.9°C, travertine: 26.1°C, empenyel wood: 28.9°C, andesite: 27.1°C, soil: 27.5°C and asphalt: 28.5°C); PET value was calculated as 26.3°C in the first project in which surfaces mostly covered with grass and travertine; in the second project mostly covered with wood and asphalt, PET value was 28.1°C; and finally in the third project, PET was calculated as 27.02°C. In conclusion, design based suggestions related to the use of floor materials in urban areas are made for decreasing urban heat island effects and for designing comfortable places in hot climate cities.

Keywords: Landscape design comfort, PET, landscape surfaces, temperature control

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Impact of Urban Morphology on Average Urban Albedo

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A three-dimensional Model for Urban Surface Temperature (MUST), which consists of a rigorous radiation scheme on the urban surface for a complex city, is used to investigate the impact of canyon geometry on average urban albedo. The model performs well in terms of predicting urban albedo. Urban albedo is defined as the ratio of incoming to outgoing shortwave radiation at the upper edge of the urban canopy layer, the value of which may vary throughout the time. Thus, we introduce an average urban albedo of a day to eliminate the time effect. Three scenarios are tested in the research, in order to study the impact of canyon density, building height and building height uniformity on the average urban albedo. The estimated results of the urban average albedo for different canyon geometry shows that the medium-density urban absorbs the solar radiation most and the average urban albedo is found to decrease with increasing building height. Also, more solar radiation will be absorbed as the geometry getting disordered. Overall, the average urban albedo is less for a moderately compact city having high-rise buildings with varying building heights than other cases.

Analysis of human thermal conditions in winter for different urban structures in Erzurum

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Healthy urban planning and urban modelling is necessary for sustainable urbanization. For this purposes, this study was carried out in the city of Erzurum located 2000m altitude. It is the coldest city in Turkey started urban transformation projects in the last few years. Four different parts of the urban areas are decided for the case study as Erzurum city center (1), Botanic garden of Ataturk University (2), Yenisehir (3) and Dadaskent (4). PET and SVF were measured in these areas and measurements were made at 9:00, 12:00, 15:00 and 18:00 because they are peak hours in which people are using outside places in winter months (December- January - February). Life comfort, which is the issue tried to be measured in this study, is extremely important for long winter period cities. In addition to PET and SVF, Landsat satellite images are used for the measurement and in this process; different categories are defined for determination of alteration in the heat islands. In conclusion, related to the structural and plant design in urban areas, design based suggestions are made for increasing urban comfort.

Keywords: Urban design, PET, Winter comfort, SVF, Thermal Band, trees

Urban Microclimate: A new software development for urban design and planning with urban heat island effect

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Urban Microclimate is an urban design simulation tool that provides climate-specific advice for cityscape geometry and land use to assist the development of energy-efficient cities that are also thermally comfortable. The software enables urban designers to parametrically test built densities for masterplanning and urban planners to advocate zoning regulations such as building height and land use as well as policies for traffic intensity with energy and thermal implications of these interventions. Urban Microclimate is the first tool publicly available that incorporates microclimate analysis in urban design and energy simulations.

The tool uses Urban Weather Generator (UWG) [Bueno et al, 2014] to model urban heat island effect (UHI) from measurements at an operational weather station based on neighborhood-scale energy balances. The recent evaluation against field data from a network of weather stations in Singapore represents a range of land uses, morphological parameters and building usages that the UWG is able to simulate. In an effort to create a usable and accessible urban design software, sensitivity analyses for Singapore and Boston, MA, USA are conducted to identify as key parameters the building morphologies such as horizontal building density and vertical to horizontal built ratio; building surface albedo and emissivity; and sensible anthropogenic heat in the urban canyon. The commonality of results for these cities allows reduction of user inputs to the model by 80% without reducing the simulation accuracy.

The newly proposed workflow for energy- and thermal comfort-driven urban design and planning is demonstrated through a case study of the new 1.4 million square feet development in Cambridge, MA, USA. Multiple urban development scenarios of different massings and construction materials are tested in parallel through the Urban Microclimate’s graphical user interface. Each design is evaluated and then ranked according to its effects on UHI and heating and cooling energy consumptions to allow users to quickly target and adopt strategies that are most effective for the specific climate and urban morphology for a sustainable urban growth.

Research on the outdoor climate distribution and effect for the air-conditioning load of a thousand-meter scale skyscraper

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As one of the important future trends of skyscraper, it is necessary to carry out prospective studies about the construction of the thousand-meter scale skyscraper. Due to the special nature of the meteorology element distribution, the air conditioning (A/C) load and energy consumption characteristics of the thousand-meter scale skyscraper differ from the common building significantly. This paper analyzes the effect of height on the A/C load for a hypothetical thousand-meter scale skyscraper in Dalian by both the energy simulation software TRNSYS16 (Transient System Simulation Program) and the mesoscale meteorological model WRFv3.4 (Weather Research and Forecasting Model). We calculated the weather conditions of Dalian by WRFv3.4 and get the variations of the meteorology element along the vertical direction in different seasons. Based on the vertical distribution of the meteorology element concerned with the calculation of building A/C load, we modified the database of TRNASYS16 according to the result from WRFv3.4, and calculated the A/C load of each room at different heights in the hypothetical thousand-meter scale skyscraper with the modified database by TRNASYS16. The results show that the cooling load gradually decreases with the increase of the height, and the heating load becomes larger as the height rising .The room cooling load at the height of 1000m above the ground was about 30% less than that close to the ground.

Implementation of the TEB model as a new TRNSYS-TYPE for the Assessment of Urban Microclimate prior to Dynamic Building Thermal Simulation

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The paper addresses the necessity of coupling urban climate and building energy models when investigating the energy demand of urban buildings. It reports on a new Type for use in TRNSYS named Type 201, which is a new implementation of the urban canopy model "Town Energy Balance TEB" of Masson (2000) - when used in offline mode - for non-stationary building energy modelling, and which aims at coping with the non-availability of urban climate modelling routine within building energy tools.

The TEB-Type simulates under TRNSYS the urban microclimate and enables to adjust the standard climate data usually originating from rural sites to urban context prior to building energy simulation. This overcomes the lacking consideration of the microclimate changes like urban heat island effects, due to the surrounding built environment which constitutes the real boundary conditions of urban buildings.

The model TEB has some features which makes it favorable for a combination with TRNSYS, e.g.: 1) Compatibility with TRNSYS: Simulation at hourly basis, for 1 year, e.g. with TRY standard climate data, 2) Short simulation time: 2-3 min./ Simulation and 3) Detailed description of urban canyon facets as multi-layered components (street, roof, wall).

Type 201 provides all terms of the energy balance at each surface (street, roof, wall) so that the physical processes prevailing in the formation of a specific urban microclimate can be explained. These include for each urban facet: The total absorbed short-wave radiation, long-wave radiation, total net radiation, the sensible and latent heat fluxes, the heat storage, the anthropogenic heat flux, as well as the single surface temperatures, the prognosticated air canyon temperature.

The new TEB -Type is very versatile and allows large parametric runs with minimal input preparation. The new implementation of TEB in TRNSYS also solves a number of disadvantages of the original tool: 1) The low user friendly graphical interface under LINUX, 2) the time-consuming pre-processing and lack of consistency check of the inputs and the too large outputs files for each key metric and 3) The fragmented source code which is rather difficult to decrypt by an end-user.

Exemplarily, an application of the Type 201 is given by showing the microclimate effects of urban facets properties (street, rood, walls). Different constructions are systematically compared including 3-steps variation of thermal insulation levels, thermal inertia and urban density. The results confirm that the canyon is mostly warmer and the daily air temperature patterns are influenced by each of the investigated parameters. This advocates for a systematic prior consideration of microclimate changes in Building energy modelling.

The Type 201 partly solves the methodological problem of lacking connection between building climate and urban climate simulations. Yet, the paper discusses the potential of further development of such a type towards a more extensive coupled urban canopy and building energy model for synchronized dynamic simulation of outdoor and indoor energy balances and climates, i.e. including their interactions at each time step.

This coupling requires eliminating the redundancy in calculating the energy budget at the urban facets which are the shared surfaces between the two entities. This currently occurs in TRNSYS and TEB with different methods. This further development is set as next task.

Urban weather generator: a method to predict neighborhood-specific urban temperatures for use in building energy simulations

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The Urban Weather Generator (UWG) is a simple and computationally efficient model that predicts canopy level urban air temperature using meteorological information measured at a reference weather station. Intended for use by architects, planners and building service engineers, it simplifies the inherent thermal coupling between buildings and the urban canopy and requires a level of user expertise and computation time commensurate with typical building design workflows. To map typical or annual meteorological year weather files to an urban weather file in the same format, UWG uses four submodules: the rural station model, vertical diffusion model, urban boundary-layer (UBL) model and urban canopy and building energy model. The near-universal nature of the urban weather file makes it compatible with widely used building energy simulation programs. Decoupling the production of the urban weather file from the building energy simulation requires the user to represent within UWG the thermal characteristics of existing or proposed buildings with reasonable accuracy. Comparison with an iterative coupling of buildings with urban canyons shows satisfactory performance. Access by designers to urban and building parameters required by UWG is assessed.

Improvements to the model, allow the user to define and describe different urban neighborhoods. Thermal interactions between neighborhoods are modeled as occurring through vertical transport of heat by convection and radiation from the urban canopy to higher regions of the urban boundary layer and advection of that heat, where the warmer UBL interacts with downwind neighborhoods. Designers can also specify the weighted presence of different building uses (i.e., commercial, residential, industrial) in each neighborhood. An upgraded representation of the energy balance in the UBL uses the known physics of longwave radiation in participating media to define an equivalent sky temperature. The current UWG also provides an improved representation of the effects of surface roughness on airflow.

A recent comparison of model predictions and measurements in Singapore will be presented and compared with previous validations in two mid-latitude cities. The comparison in Singapore shows satisfactory performance of the model for all weather conditions. Somewhat unexpectedly, the choice of two reference weather stations in Singapore, one near open water and the other in the interior of the island, has minimal impact on the estimation of diurnal temperature patterns in targeted neighborhoods. Analysis indicates that vertical energy exchange dominates the impact of advection in the UBL. However, the temperatures at the two reference stations are not identical and differences between neighborhood temperatures estimated by the UWG and the reference station, which show the magnitude of the urban heat island effect, depend on the choice of weather station. In aggregate, validations to date show that the model can be applied to different climates and urban configurations to obtain an estimation of the Urban Heat Island (UHI) effect. The spatial specificity and accuracy of these estimates are assessed in the context of building performance.

Translating the Urban Heat Island effect into power consumption for space-cooling: A case-study of megacity Delhi, India

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Globally, urbanization has altered the surface heat flux and the emission flux which has significantly affected the micro and macro climatic trends. Urban Heat Island (UHI) phenomenon, altered precipitation cycles and the extended green house gas effect are one of the few artificially induced global environmental hazards. UHIs significantly affect the health of the people, the energy consumption and the overall environment. Delhi, the capital of India, has witnessed rampant urbanization in the past few decades. This change in the land use / land cover has resulted in the formation of many micro-urban heat islands which have altered the macro and micro climate of Delhi. The present study attempts to put light on the growth of the UHIs across Delhi and translates the UHI effect into power consumption for space-cooling. Remotely sensed annual land surface temperature for the duration 2001-2011 and the field campaign done for collecting ambient temperature and relative humidity across 30 locations during 27-28 May, 2008 were used for micromapping the UHIs of Delhi while multiple micro-climatic data was used for simulating the impact of UHI on power consumption for space-cooling using a building energy model. The mapping of the land surface temperature was done using Geographic Information System (Arc GIS 9.3) while building energy model 'eQUEST' was used for energy simulation. The UHI maps were further interfaced with the land use / land cover maps and the population maps.

The results reveal that the UHI intensity across Delhi was as high as 8.3°C. Moreover, the high UHI intensity zones almost remain unchanged but new zones of moderate UHI intensity appeared. The building energy simulations done using the multiple micro-climatic data representing various land use / land covers like built-up canopies which includes dense, medium dense and less dense, forest canopy, water body and rural canopy reveal that the UHI effect has significantly increased the power consumption. In the background of the urbanizing process, the paper thus discusses the changing micro-urban climate viz.-a-viz. the UHI effect across Delhi and its impact of the power consumption for space cooling.

Sensitivity of electricity consumption to air temperature, air humidity and solar radiation in city-block scale – Based on 2013 Osaka city observation

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The urban heat island (UHI) phenomenon has been more accelerated and the outdoor air temperature (OT) has become higher. Such OT rise is posing an increase in electricity consumption (EC) for air conditioning. Nowadays, many UHI countermeasures which are reflective paint, water-retentive pavement, sidewall greening, and so on are developed and installed in order to mitigate OT and reduce energy consumption for air conditioning. However, these countermeasures can bring adverse effects on the society. For example, water-retentive pavement increases outdoor air humidity. It can increase EC for air conditioning through lowered efficiency of air conditioners due to dew condensation. Sidewall greening cuts penetration of solar radiation (SR) into the room through the windows. It can increase EC for lighting. Needless to say, reflective paint can increase EC for heating because it decreases OT in winter.

Therefore, we need to understand a quantitative relationship between the energy consumption and the meteorological elements such as OT, air humidity, and SR throughout the year for reasonable installation of the UHI countermeasures. Thus, we aimed at quantifying sensitivities of EC to meteorological elements in city-block scale. The reason that we chose finer scale is that the countermeasures are installed in small areas.

We installed meteorological instruments to the rooftops of fifteen primary schools in both of business and residential districts of Osaka city, which is the second largest city of Japan. The meteorological data which are OT, relative humidity, and SR were measured from March 2013 to March 2014. Then, we calculated the sensitivities of EC to meteorological elements using the multiple regression analysis. The concept of our methodology is similar to cooling and heating degree days. It is explained as follows by taking air temperature as an example. EC increases by heating in winter when OT becomes lower than a certain temperature. We define this certain temperature as a branch point of winter OT. We also define the increment of EC by OT decrease as a sensitivity of EC to winter OT. EC increases by air conditioning in summer when OT becomes higher than a certain temperature at the same time. A branch point of summer OT and a sensitivity of EC to winter OT are also defined. Thus, hourly EC is separated to base load and air-temperature related parts.

Our analysis showed that the branch points of summer OT in the business districts were lower than that in the residential districts. It is suggested that office automation equipment leads to the air conditioning demand. The branch points of summer OT in the residential districts were around 28 degree in the early afternoon (from 13:00 to 15:00). These values were higher than we thought and suggested that the residents in Osaka city are saving electricity because all of the nuclear power plants of Japan are still shut down.

The branch points of winter OT in the business district were similar to that in the residential districts. The sensitivities of EC to winter OT in the business districts were larger than that in the residential districts. However, ratios of the sensitivities to the base loads in the business districts were smaller. These results show that the air conditioners in the residential districts had a more significant impact on EC.

Specific humidity (SH) is considered to be related to EC because dehumidification on the fan coils in the air conditioner occurs and leads to EC. We analyzed branch points and sensitivities of summer OT and SH during only summer. The branch points and sensitivities of summer SH were the similar tendency of those of summer OT.

SR affects room temperature and illumination. SR enters through windows and becomes heat the air in rooms while the entered SR illuminates the rooms. We found the existence of branch points of SR during no air conditioning period. The residents were considered to begin to turn the lighting on at this point.

Comprehensive validation of a simulation system for simultaneous prediction of urban climate and building energy demand

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The outline of the authors' ongoing research project concerning the interaction between energy demand and urban climate will be presented with the latest results. The goal of the project is to substantiate the performance of the authors' numerical simulation system for simultaneous prediction of urban climate and building energy demand with the spatial resolution of 1km and the temporal resolution of 1 hour throughout a city and a year. The system has been originally developed and consists of the mesoscale Weather Research and Forecasting (WRF) model and a coupled multilayer urban Canopy Model and Building Energy Model (CM-BEM). The latter CM-BEM is original one and was developed as the first coupled system of Urban Canopy Parameterization and Building Energy Model (UCP-BEM) about 10 years ago. CM-BEM can simulate the feedback process of the sensible and latent anthropogenic heat from HVAC systems of the urban buildings to the atmospheric heat balance in the urban canopy layer. The project is being carried out based on field observations in the third largest Japanese city Osaka.

In order to obtain actual measurements used for validation of the simulation system WRF-CM-BEM, the project team carried out a yearlong field campaign in Osaka in fiscal year 2013. The meteorological measurements were conducted in the 15 urban areas (3 downtown commercial areas, 9 residential areas, and 3 mixed-use areas) at a couple of rooftop and ground sites in each area. Those sites composed an original high-spatial-resolution network for urban climate observation with mean distance between the sites less than 4km. Additionally thanks to cooperation from an electric power company, the project team obtained areal and hourly electricity demand data monitored at 13 distribution substations each located in 13 observed urban areas with horizontal dimensions of 500 m to 2 km square each.
Those yearlong meteorological measurements and electricity demand data was used for the validation. Furthermore to check the potential of WRF-CM-BEM as an urban energy management tool especially in the prediction of photovoltaic power generation, the solar radiation was also monitored at all rooftop sites, and its intraurban spatial inhomogeneity was analyzed. Then the derived statistical characteristics of the observed insolation inhomogeneity were also used for the validation.

As a result of analyses of the yearlong observed insolation, it was found that Mean Absolute Percentage Deviations (MAPD) of the observed 5-minutes-averaged insolation at each site from that at the downtown reference site reached up to 40% indicating relatively large intraurban insolation inhomogeneity. Those MAPDs especially became larger on lightly and partly cloudy days than those on sunny and overcast days due to partly cloud cover in the sky. Those statistical characteristics of insolation inhomogeneity were able to be roughly reproduced by WRF-CM-BEM suggesting its potential application to evaluation of photovoltaic power generation. Additionally WRF-CM-BEM showed a good performance in terms of reproducibility of the near-surface urban climatology over Osaka especially in the surface air temperature. As a result of WRF-CM-BEM simulations, the Root Mean Square Error (RMSE) and Mean Absolute Percentage Error (MAPE) between the observed and calculated summer 2m-height air temperatures over Osaka indicated less values compared to those in the latest relevant study which adopted an official UCP-BEM option named "BEP +BEM" in the WRF simulations for Phoenix USA. Lastly the reproducibility of the areal building electricity demand was validated. WRF-CM-BEM was found to be able to reproduce the observed contrast in the building electricity demand between downtown commercial areas and uptown residential areas quantitatively.

Thus the promising performances of WRF-CM-BEM for simultaneous prediction of urban climate and building energy demand were finally confirmed with its suggested potential application to the prediction of photovoltaic power generation toward the contribution to "smart grid" technology.

Exploiting urban physics - A ‘Form First’ Approach to Sustainable Urban Development

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Building and urban form are recognised to modify the background climate by changing the solar and wind paths and by trapping both heat and pollution. These modifications are site specific and often results in uncomfortable urban environments, which in turn increases building energy demand. However with careful consideration these interdependent energy relationships (between form and climate) can be optimised to improve the urban environment, which in turn not only lowers energy demand, but improves the efficiencies of so-called ‘generic’ low energy technologies (for example, façade design and renewable/passive systems), alongside improving the health and wellbeing of urban residence.
Whilst the significance of these urban climate effects on both internal and external environments is acknowledged, for the most part they fall outside the broader discussion on sustainable urban development. This is evident by the lack of suitable tools, methodologies and guidelines to measure and incorporate these effects into the design of urban places, limited to a consideration of aesthetic values e.g. views, and impact assessments e.g. rights to light.

The energy and environmental management of our urban environments is more complex than dealing with the particulars of an individual building or relying exclusively on renewables to reduce the impact of climate change and the growing energy crisis. There is a growing need for methodologies that are capable of dealing with the many variables that exist in our urban systems.

London is experiencing a radical changes to the city’s urban morphology and infrastructure. The city, already populated with many tall buildings, is expected to experience a rapid change in response to modern concerns that include a desire for taller buildings, higher density and sustainable urban design (including energy efficient buildings and high-quality outdoor spaces). However architectural decisions (individually and in aggregate) are key to achieving both local and global objectives of sustainable urban development; nonetheless, to achieve this, it is critical to recognise the interdependent energy relationships that form between buildings at the neighbourhood scale.

This work reports on the impact of London’s changing skyline on both the urban climate and building energy needs, and investigates through a series of studies that are concerned with the difference in regulated loads of modern building types in their standalone setting (as is current practice) against identical buildings in various urban settings. The work will establish direct links between ‘form’ driven microclimate generation and building energy management at neighbourhood scale. In doing so the work will lay the foundation for the improved efficiency of ‘generic’ methodologies, further increasing London’s sustainable credentials.

The overall aim of the work is to outline a broad planning framework to guide future urban development in a climate sensitive manner.

Could urban climate modelling systems provide urban planning guidelines in the context of building energy performance issues?

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To date, the urban sprawl has accompanied the 20th century rapid urbanization. It results in particular in the artificialization of vast natural surfaces and fragmentation of the landscape. The latter is regularly pointed out in the ecological studies as it dramatically alters the ecological diversity. Indeed the postulate is that large ecological reserves, the area provided to the species for their usual activities, home higher species diversity. With the Grenelle 1, the biodiversity preservation and the control of the urban development especially to save energy and protect environmental resources become the local authority policies' priorities. Both could be achieved by promoting the urban densities, the urban renewals or by preserving species reserves that are necessary to maintain the connectivity of the ecological network.In parallel the changing of moist surfaces by impervious construction materials characterized by a high roughness and heat capacities alters the surface-atmosphere energy, momentum, and radiations exchanges. The urban heat island is originating by such land changes and depicts the formation of a buoyant efficient turbulent convective and extended boundary layer downstream built-up area. Several numerical studies highlighted its influence on seasonal building energy requirement patterns for space heating and cooling over megacities using physically based numerical urban climate modelling systems and finest grid resolutions ranging from 1km up to 250m.

The first research objective of our study is to test the ability of the numerical urban climate modelling system to consider high resolved and small land cover changes using the WRF-BEP+BEM urban modelling system. The second objective is to quantify the energy performance of six contrasted urban developments scenarios.

The urban development control and species reserves preservations policies have been translated into non-developable lands maps using the Graphab and Morpholim softwares developed at ThéMa (Besançon, France) while the SLEUTH* model of Doukhari et al. (2011) is used for simulating the six scenarios urban development that in turns serve providing the surface boundary conditions to the climate modelling system. The study has been performed over the intermediate populated urban region of Strasbourg-Kehl (France) taking into benefits the existence of up-to-date and high resolved building and land use land cover data. The urban development by 2030 is considered. The results show that urban climate modelling system in our study achieves reproducing global built-up patterns features but has difficulties to consider high resolved land cover changes that are of the urban planners resolution. The methodology and the results will be both presented and discussed.

Building Energy Demand under Urban Climate and Climate Change conditions with consideration of Urban Morphology and Building Typology - GIS Mapping of the City of Stuttgart

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This paper reports on preliminary results of the ongoing KLISGEE project which addresses the issue of quantifying the consequences of the urban climate and mid-term climate change on the energy demand of buildings for the case of Stuttgart, Germany. The method applied combines 1) numerical modelling using TEB and TRNSYS, 2) statistical analysis for pre- and post-processing of the data and 3) GIS-methods.

Information about the city is required, including weather data from atmospheric model for the period 1971-2000 and 2021-2050 with hourly temporal and 2.8 km spatial resolution, interpolated observed weather data from the hydrological LARSIM-model for the period 2003-2012 with hourly temporal and 1 km spatial resolution, 2D and 3D city maps in high resolution, data about use and age of buildings, statistical data of traffic and residents etc.

The high spatial resolution of the weather data enables a better description of spatially differentiated local climate due to the distinctive topography of Stuttgart.

First, the weather data are further corrected by means of the urban canyon model TEB in order to take into account the microclimatic effects of the various urban structures (urban density, land use, land cover, residential density and traffic density etc.).

Second, the dynamic building energy simulations using TRNSYS are undertaken for representative urban structures and building typologies identified in the city of Stuttgart. To keep the simulation times reasonable for the huge extent of the object of study (whole city), it is necessary to proceed to a generic depiction of the urban and building typologies based on an abstraction of their thermal properties instead of their real physical description. These include decisive parameters like street aspect ratio, residential density, density of traffic, building compactness, thermal insulation, building use, window ratio, etc. The simulation series are based on a DOE design of experiment plan.

Finally, the results are post-processed statistically. The single and double interactions of the investigated parameters as well as their hierarchical importance are quantified, so that mathematical models can be derived, which are then used for the representation of the spatial distribution of the energy demand results for the whole city at urban block level by means of GIS-techniques. The key metrics are mainly heating, cooling and lighting net energy demands.

The results confirm the importance of urban climate and climate change prognosis, as well as all investigated physical parameters characterising the city. This advocates for 1) the necessity of taking climate boundary conditions into account when dealing with building modelling and 2) on the importance of a proper building design to avoid negative cumulative urban climate effects.

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Creating Urban Cool Islands effects for summer season in Toulouse new area: urban microclimate adaptation

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Urban population has been growing exponentially over the past decades all across the globe. Cities currently concentrate more than half of the world population and of around 80% in developed countries such as in France. Such concentration of people along with their different activities has produced major stress on the natural and built environment. The urbanization models are marked by important changes in the natural surfaces and in the built morphology, which have altered radiation, thermal, moisture and aerodynamic properties of these environments, leading to a new human induced climate. This urban climate has affected environmental quality of spaces, leading to human heat stress, particularly in summer conditions, and a significant increase of energy demand in buildings. This intensive urbanization process brings us to face new challenges of adapting existing and new urban areas to a progressive and local climate change, which requires integrating decisive measures right from the first stages of the design process. One of the first airmail services in the world, the Aeropostale, was located in the Montaudran airport in Toulouse-France. This landmark and its surroundings will be refurbished and transformed into a mixed-used urban site, the Aerospace valley, with residential buildings, commercial, sportive, educational and cultural activities. This new district has been recently planned based mostly on patrimonial and functional rules. The UCI project (from "Urban Cool Islands") is a national French research project that has discussed procedures aiming at incorporating a set of reasoned measures of local climate adaptation to this new urban area that will be set as landmark reference. This research aims at analysing and comparing different adapted and resilient urban design strategies to provide support for their application in the Montaudran district plan, focusing on mitigating urban heat island effects in summer season conditions. Two main methodological steps were undertaken: (1) the initial urban plan was assessed relating a set of well-known energy-related parameters of the urban morphology and microclimate analysis; (2) a set of variations to adapt the initial plan was undertaken based on the local plan major guidelines and on main climate adapting measures. Results pointed to a major influence of the water bodies and vegetation density on the mitigation of urban heat islands, notably in daytime. The increase of vegetation density all along the ancient airport runway allowed creating an important urban cool island for pedestrian walk, reducing drastically local heat islands effects.

Urban microclimate and building energy: a coupled simulation approach

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Nowadays, a large share of buildings are built in urban context. Therefore the various interactions between buildings and their urban environment should be carefully considered when dealing with building energy or micro-climate simulation. A building is exposed to a local microclimate, surrounded by other buildings that mask solar inputs and/or trap long wave radiation. On the other hand, the microclimate is very sensitive to anthropogenic heat gains from HVAC systems and roughness of urban canopy.

In addition, one of the main concept for low-energy or passive buildings is to rely massively on free heating and cooling ressources, such as solar, occupancy and outdoor air to satisfy their needs. As a consequence they are much more insulated to decrease their needs. From a certain point of view, they are paradoxically disconnected from their environment but also very sensitive to outdoor air, solar and long wave radiation through windows and ventilation.

Therefore, when designing a new building in the early stages it is important to take into account its interactions with surronding buildings and the microclimate. It supports optimization of the building's energy performance in more realistic conditions as the one of the overall district. Consequently, there is a strong need for tools capable of performing urban energy simulation taking into account buildings and their surroundings based on available data.

The French ANR project MERUBBI aims at developing an interdisciplinary method based on building energy, radiation, microclimate and economics analysis. Assessments of various indicators, for resources exploitation and economics consideration for instance are then carried out for optimizing the overall system.

In that context, we developed a tool-coupling framework between BuildSysPro, EDF's Modelica library for building energy simulation, Solene-Microclimat, a urban microclimate simulation tool developed by the CERMA and ArchiWizard, a ray-tracing solution from HPC SA.

We applied our methodology on a real district, the test case being the construction of a new building in the already existing district of Nantes Ranzey in France, composed of 25 buildings. The process was unfold from the architectural plan taken from the cadastre to the Modelica energy simulation. The results show a 20% increase in annual heating demand compared to the same building in a remote location used as reference.

The urban heat island and its influence on building energy consumption in England and South Korea

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This paper examines the measurements of the urban heat island in a number of sites around Manchester, England, UK and also Ulsan in South Korea. The measurements and the actual weather are considered and compared and the possible reasons for the different urban heat islands are discussed. Although a significant urban heat island intensity (UHII) is found in the UK site it is not as high as the intensity in South Korea. However, the UHII is steadily rising in the UK but it is not in South Korea. A number of identical commercial office buildings are then simulated with and without the UHII added. The increase in energy consumption in the warm periods is increased by the UHII by about 8% in the UK and almost 20% in South Korea. The heating in cooler periods is consequently reduced but not by as much as the summer cooling. The glazed area of the buildings is also influential in the energy used.

Assessment of urban cooling strategies impact using a coupled model for urban microclimate and building energy simulation

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The EVA project is being carried out to evaluate the cooling efficiency of three types of systems:

• Vegetation (tree, green wall and green roof),

• Water (watering road),

• High albedo values (Cool paint on walls or roof).

This study is realized thanks to two numerical modelling scales. The first one is a district scale while the second is a higher scale containing several districts in order to evaluate the impact of districts on one another. Three models are used for this study: Solene-microclimat (Malys, Musy, et Inard 2014), EnviBatE (Gros, Bozonnet, et Inard 2011) and ARPS-canopy (Maché 2012).
The assessment of these different strategies is applied to an existing district: Part-Dieu in Lyon, France. This district has a high urban density and is composed of buildings which rehabilitation is expected to be difficult. It is particularly sensitive to summer heat waves which frequency of occurrence will increase with global warming. Three places were chosen for this study: Moncey Street, Francfort place and Buire Street.

Two different methods are used to evaluate the cooling efficiency of each strategy. The first consists in studying different urban planning corresponding to each type of system. The second one is to study a single urban planning but with climatic data that take global warming into consideration. The systems will be evaluate by studying their impact one microclimate (microclimatic variables and outdoor comfort), on indoor comfort and building energy demand.

In this paper we present the results obtained with the EnviBatE model. Among the three places, two will be evaluated using EnviBatE: Moncey Street and Buire Street. They represent respectively 60.000 m² and 70.000 m² and are composed of about ten building blocks. EnviBatE is used to compute the building energy demand and the microclimate for a seasonal period (from the first of May to the 30th of September). Modellings are realized for standard meteorological data and for data taking into account the global warming .The results show the impact of the different cooling strategies on the urban microclimate and building energy demand.

Outdoor human comfort and climate change. A case study in the EPFL campus in Lausanne

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The increase of the population, the growing urbanisation and the climate change are the present challenges for a sustainable urban development. This paper proposes a methodology to study how the microclimate and the analysis of the outdoor human comfort in the built environment can influence the future city design.

The methodology makes use of an Urban Energy Modelling tool to define the energy demand of buildings and the outdoor conditions, considering the energy exchange between pedestrians and the urban microclimate. The model of the EPFL campus in Lausanne (Switzerland) is analysed with the software CitySim and ENVImet, showing the actual energy demand of buildings, the microclimatic map of the site, and the outdoor human comfort according to different biometerological indexes. The dynamic model of the site, in the present scenario, is validated with on-site monitoring: the buildings energy demand (correlation factor R^2=0.89), the BiPV power plant model for the solar electricity produced on the EPFL buildings roofs (correlation factor R^2=0.93) and the Mean Radiant Temperature model (correlation factor R^2=0.92). The model is then analysed, according to the International Panel of Climate Change (IPCC), in three different future scenarios (B1, A1B and B2) for 2050 and 2100. The models show the impact of climate change in the energy demand of buildings, and in the urban microclimate. Two hypothetical refurbishment of the site, according to the Swiss Minergie and Minergie-P labels, are proposed to reduce the energy demand of buildings. Passive cooling strategies are applied in the future outdoor environment, able to decrease the hours of discomfort of pedestrians, according to their metabolic activity. Finally an optimal solution for 2050 is defined, which reduces the energy demand for heating and cooling (by 37% compared with the current thermo-physical characteristics of buildings projected in 2050), and ensures a comfortable outdoor environment for pedestrians during the different seasons.

This paper contains the simulations methodology, the simulations results and gives some insights about how to improve sustainability for the future urban design.

Keywords: outdoor thermal comfort, climate change, urban energy simulations

Taking into account building environment in the energy consumption evaluation

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In a context of new building regulations, buildings in France have now to be designed to keep their annual consumption under 50 kWh/m².year. Futur regulations could lead to build buildings which won't require any energy and will be able to ensure thermal comfort in summer. This substantially increases the need to use tools able to evaluate thermal behavior of buildings in a very precise way. In particular, evaluating heating and summer comfort needs at architectural design step become more and more crucial.

One of the main improvement which can be brought to the dynamic thermal simulation tools is to better consider the whole environment of the studied building. In particular, the long wave radiation exchanges between all buildings of an urban scene need be taken into account.

The aim of the study is to quantify the impact of considering infrared radiation exchanges between the building whose thermal behavior is simulated and its whole urban environment. The modifications of the infrared radiation fluxes are analysed and its impact on both energy needs and thermal comfort are then investigated.

Numerical simulations were carried out six buildings inserted into different French districts (three in Lyon and one in Nantes, Strasbourg and Paris) with different building densities. The 3D numerical tool takes into account the unsteady building thermal behavior using the SOLENE thermo-radiative model to evaluated both solar and infrared radiations. The urban surfaces are meshed into triangles on which energy balance are compute to estimate temperature. These surface temperature are coupled with the building thermal multi-zonal model which considers each floor of the building.

The six buildings are first studied without and then with their urban environment. Infrared radiation values modification between the two situations are analysed for the six buildings. As infrared radiation depends on the temperature surfaces involved in the case study, simulation for both summer and winter situations are carried out. The influence of the infrared modifications on energy need is evaluated in winter and on the thermal comfort in summer.

The results are analysed to compare the average infrared radiation received by the studied building. The infrared radiation distribution on the building surfaces are also investigated in order to have information about the dispersion of the values around the average infrared radiation. The influences on thermal comfort and energy consumption are given in regards to some indicators representing the building density. These results are expected to be able to provide precious information about the situation where it is (or not) necessary to take into account the influence of the urban environment in dynamic thermal simulation models.

Urban Greening and the UHI: Seasonal Trade-offs in Heating and Cooling Energy Consumption in Manchester, UK

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In the UK, climate change projections estimate that mean summer air temperature will rise by approximately 3.5 °C by the 2080's (medium emissions scenario, 50% probability level, 1961-1990 baseline). For urban areas, increasing the proportion of greenspace is an adaptation strategy that is often suggested. While numerous studies have investigated the cooling effect of greenspace in terms of both air and surface temperatures, few studies have further investigated the links to building energy demand.

This research presents an interdisciplinary approach to model fine-scale microclimate changes due to greenspace additions, using the results to develop customised weather files for modelling building energy consumption in commercial buildings. The CBD was modelled with the microclimate model ENVI-met with a range of greening scenarios for a summer day in July 2010. Both modelled and measured microclimate data were then used to develop a series of weather files for building energy modelling of three commercial building types (a three-storey shallow plan, a 10-storey shallow plan, and a three-storey deep-plan).

For the most effective scenario of adding 5% mature trees to the urban case study, the microclimate modelling estimated a maximum hourly air temperature reduction of nearly 0.7 °C at 5 pm. The building energy modelling estimated a reduction of 2.7% in July chiller energy due to the combination of reduced UHI peak hours and eight additional trees (four on the north side and four on the south side) surrounding a three-storey shallow plan building, with savings increasing to 4.8% under a three-day period of peak UHI conditions. While winter boiler energy usage is substantially reduced for a building in an urban location with a low proportion (approximately 3%) of greenspace, the wintertime benefit is marginal when analysed in terms of carbon trade-offs between summer cooling and winter heating requirements.

Impact of increasing the depth of urban street canyons on building heating and cooling loads: Case study of Tel Aviv, Israel

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Many of the existing buildings in Tel Aviv's older neighbourhoods suffer from structural weaknesses and might collapse in the event of a major earthquake, of which there is a high probability. Israel's National Guideline Plan 38 (NGP 38) seeks to address this problem, facilitating the renovation of unsafe buildings by allowing construction of additional floors in existing buildings undergoing reinforcement, thus providing a financial incentive and a suitable regulatory framework. However, the increase in urban density, although desirable from other aspects, may also be expected to exacerbate the urban heat island.

The study examines the potential effects of increasing building height by means of computer simulation. The Canyon Air Temperature model is used to generate site-specific weather data from time-series measured at a reference weather station, accounting for urban geometry, materials and surrounding land cover. These data are used as inputs for assessing:

a) The 'climatic cooling potential', a metric that estimates the potential for cooling by ventilation in a non-air conditioned building whose temperature is assumed to oscillate harmonically in response to the diurnal cycle of external air temperature, with a time lag and decrement factor that are due to the presence of thermal mass.

b) Heating and cooling requirements in a fully air conditioned building, using the EnergyPlus building thermal simulation software.

Both indicators were calculated first for the reference weather station (Bet Dagan); then for conditions in typical existing streets in southern Tel Aviv; and finally for different scenarios of increased building height, up to a total of 8 floors. The simulations confirm that deeper streets resulting from implementation of NGP 38 are likely to create more intense nocturnal heat islands and to reduce wind speed.

The buildings modelled are typical of those found in the older quarters of Tel Aviv, with concrete block walls and flat concrete roofs with minimal thermal insulation. Windows are small, single-glazed and display no preferred orientation. Although any major retrofit may include a thermal upgrade, the study assumed that additional floors would be identical to existing ones, to focus on the effects of possible modifications to microclimate. It was found that the expected increase in cooling needs from higher air temperature was tempered by the effect of mutual shading by adjacent buildings. Annual consumption was further reduced by a decrease in heating. And, because intermediate floors are less exposed to the environment than a low-rise house, they require less heating and cooling. The compound effect, in this case, is that despite causing a more intense UHI, adding floors to low-rise buildings may reduce annual specific energy consumption, from about 34 kWh/m2 for a 1-floor building to about 26 kWh/m2 for a 7-floor building.

The effect of elevated night time air temperature in Tel Aviv is reflected in the values of the Climate cooling Potential. In reference weather station the total cooling potential for the month of July is 947 degree-hours; the comparable value for an exposed area near the sea is only 744 degree-hours, because nocturnal cooling is moderated by proximity to the sea. When the effect of existing 2-story buildings on air temperature is included, the cooling potential is reduced slightly to 696 degree-hours. Increasing building height to 4, 6 or 8 floors results in further reduction of the potential to 521, 374 and 178 degree-hours for the month of July, respectively.

Thus, the finding that the impact of the proposed construction on building energy consumption may be minor should be qualified by noting that assumptions regarding occupant behavior, including thermal preferences and the thermostat set points for heating and cooling, may in fact have a greater impact on energy consumption than changes in meteorological conditions. Furthermore, as the reduction in the Climate Cooling Potential indicates, occupants of non-air conditioned buildings would suffer disproportionately from elevated nocturnal temperatures and reduced wind speed on warm summer nights – encouraging use of air conditioning that may otherwise have been avoided.

Holistic Method on Performing Microclimate Analyses of an Urban Area in the Tropics

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The world has experienced unprecedented urban growth in the last century. For the first time in history, more than half of the world population were urban dwellers in 2008. United Nations estimated that by year 2030, up to 5 billion people will live in urban areas, or 61% of the world's population.

Consequently, cities are growing towards megacities with higher density urban planning, narrower urban corridors and more high-rise urban structures. Increasing urbanization causes the deterioration of the urban environment, as the size of housing plots decreases, thus increasing densities and crowding out greeneries. Within the built environment at micro-scale, buildings and vegetation influence the incident solar radiation received by urban surface.

Within this context, urban planners have the responsibility to create not just livable and aesthetic cities, but also environmentally friendly to promote a sustainable society. Hence, it is significant for the planners to understand the microclimatic impact of their design before it is implemented in the master plan.

This paper tries to demonstrate a set of microclimatic analyses of a hypothetical precinct which deals with several aspects, such as outdoor temperature, greenery impact, urban ventilation, district energy performance, and outdoor thermal comfort. In the past, these studies have been done in such a segregated and isolated manner; where one usually focuses on a particular aspect without acknowledging others. The studied precinct was developed with parametric approach, results in multiple design layouts and forms, where each of them has undergone several microclimatic analyses for benchmarking process.

The first part of this study deals with thermal load performances which comprises district sensible cooling load and external heat gains. Furthermore, the wind aspect has been analysed by using the Velocity Ratio (VR) method, which is defined as the area-averaged wind velocity magnitude extracted at a study level over the wind velocity at top of the urban boundary layer that is not affected by ground roughness and other site features. Meanwhile, the outdoor temperature analysis uses Screening Tool for Estate Environment Evaluation (STEVE) tool. STEVE tool is an empirical model that calculates the maximum, minimum and average air temperature of a point of interest based on a 50m radius in an urban area. Lastly, the analysis on outdoor thermal comfort uses Thermal Sensation Vote (TSV) index to predict and evaluate people’s thermal sensation proposed for tropical condition.

This study shows how the microclimate analyses can be done at the early stages of planning process, where planners/designers could be well informed of the environmental impact from their design. Consequently, this study tries to send a message to designers where they have to balance the design objectives on minimizing the external heat gains and at the same time reducing the heat island impact by enhance the wind outflow and implementing greenery. This approach does not have a fully diagnostic aim, such as providing exact and detail run down of performance values at the district level, but rather a comparative figures which will be useful for benchmarking different design options at the same time.

Evaluation of Smart Shading Structures in Mitigating Urban Heat Island in a districts of Hot Arid Climate City (Abu Dhabi)

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More and more the world population is concentrating in the cities converting natural areas into urbanized areas by changing the thermal properties also. As the cities evolve the local climate changes as well. And this change is shown perfectly in the Urban Heat Island (UHI) phenomenon. Indirectly the UHI increases the energy consumption used for the cooling systems inside the buildings. This is translated in additional cost and one step back into the main target of having a sustainable city.

This paper provides an overview on how with the help of different tools such as UMI, Energyplus and Ecotect we can have the results of the energy consumption of 5 different districts in Abu Dhabi, a city with hot arid climate. The energy simulations are divided in two groups. The first group includes the current energy consumption of the different typologies of buildings placed in an urban district and the results are taking into consideration the surrounding environment. The second group of energy simulation analyses the same districts taking into consideration smart shading devices spread into the different districts according to the shading butterfly provided from Ecotect. By proposing this intervention of the necessary shading in the different districts, there is a possibility to moderate the temperatures inside the buildings and as a result the energy consumption by improving in the same time the outdoor quality.

The innovation stands in the application of this smart shading structures in this type of city and the measurement tools used for such proposal. Part of the work for the energy simulation is the preparation of different templates for the selected building categories, the weather data for the hot arid climate, the use of the shoebox model and experimenting UMI as a new tool that makes this kind of simulation possible. The simulation results will be then compared with the field observation data for the different building typologies taken into consideration. This comparison helps keeping the results near to the real energy consumption conditions.

Climate-responsive residential buildings in India. Just a drop in the ocean?

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Nowadays, the building sector in India is characterized by a ferocious rhythm of construction and qualitatively poor and inappropriate to climate architectural solutions. Residential buildings mostly share the same typology, with thin walls, lack of shading systems, and lack of insulation, especially on the roof. They are vulnerable to high tropical temperatures and to extreme climate events, harboring at the same time a rising demand of better levels of thermal comfort coming from the middle-classes. For that reason, they are quickly shifting towards a total dependency on air conditioning, with consistent effects on energy consumption, health and urban climate (Heat Island Effect).

Our study proposes low-cost retrofit strategies to improve the quality of the existing stock of residential buildings in Koltata. The term “quality” makes reference here to buildings’ capacity to control the indoor environment and ensure thermal comfort for the occupants with moderate energy consumption. The suggested solutions are equally applicable to new constructions. The choice was made to privilege architectural and technical solutions and behavioral adaptations in order to avoid total dependency on air conditioning.

To this purpose, we drew on a study based on the analysis of one typical 3-4 stories building in Kolkata. The identified low-cost and technically simple interventions (such as insulation, double-glazed windows, shading overhangs, improved night ventilation) were tested through simulations and the results compared to a baseline case study (whose model was validated thanks to in situ measures recorded with data loggers). We adopted different methods to identify the indoor comfort temperature used as a reference for our simulations. We identified the most effective solutions combining reduction of indoor temperature, economic feasibility and decrease of energy consumption.

The 3-4 stories building in Kolkata represent about 85% of the existing constructions in the city; the residential building sector in India appears to be the third energy consumer, but its importance is expected to rise due to the growing rate of urbanization and equipment. In a climate-changing scenario, residential buildings will play an important role at the urban scale. This study tries to go beyond the architectural scale to consider a possible generalization of its results at the urban scale of the city of Kolkata.

Shading effect of Alley Trees and Their Impact on Indoor Comfor

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The tendency of the last decades showed that energy-efficiency in architecture means a well-insulated and airtight building shell, however these features although provide a good indoor thermal comfort in the wintertime, also increase the risk of overheating during the summer. This leads to the more frequent use of air conditioning devices providing a self-generating process from the urban heat island point of view – what's more it also increases the energy-consumption during the summer season. In order to achieve a high energy performance architects have made efforts for shading and evaporative cooling. The best tool for that is the use of deciduous plants as to improve the microclimate around the building so that the solar access is obstructed in summer. The use of Green Infrastructure in different levels of planning processes, which would provide sustainable solutions for urban management, is also prescribed in the EU Biodiversity Strategy 2020.

The significance of vegetal shading is that it can decrease the risk of overheating and also the negative effects of urban heat island. Although there are some previous data about the effect of vegetation, there are still questions in the scope of the microclimatic and energetic effect of vegetation planted in front of the façades. That is why we aimed to analyse more precisely the shading effect of alley trees, and their impact on indoor comfort. Our preliminary studies have shown that trees can effectively mitigate the heating up of building envelope due to shading. If shaded the temperature of wall surface can be ~5-6°C less opposite the non-shaded state. In addition we also showed that – depending on species – a tree in front of the façade can decrease the solar gain on internal horizontal surface up to ~43-47 per cents. As the tree obstructs the solar access of the wall and that of transparent surfaces, a difference in indoor comfort is to be observed too.

The shading efficiency of trees is a species-specific attribute, because of the varying crown structure and leaf density. Our analyses aimed at the quantification of the transmissivity of characteristic individuals of three frequently planted species (Celtis occidentalis, Sophora japonica, Tilia cordata). The measured data were the amount of transmitted shortwave radiation, compared with a measurement point under unobstructed sunlight. The highest transmissivity values (worst shading potential) was observed in case of Sophora species, the two other trees can be characterized with a bit lower transmissivity values, similar to each other. These attributes highly affect the trees' potential to improve the indoor thermal comfort and facilitate energy saving. On base of our measured data the cooling load of the buildings and the risk of summer overheating is calculated. These types of analyses can form a base for targeted model development and adaptation (e.g. i-Tree).

Energy and Comfort in School Buildings in the South of Portugal

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This work presents software that simulates the thermal response of buildings with complex topology and evaluates the indoor building climates, namely the thermal comfort and air quality in indoor environments. In this study the implementing of heating, ventilation and air conditioning systems with intelligent control, based on the PMV index, using geothermal and solar radiation energy. Instead of the traditional control based on the air temperature, the implemented system is based on the PMV index, which is based on the values of air temperature, air velocity, relative humidity, mean radiant temperature, the clothing level and the physical activity level. This methodology ensures acceptable levels of comfort, for low levels of power consumption.

The program used in this study, developed by the authors, calculates the values of air temperature inside the compartment and conduits, the temperature of opaque and transparent bodies of the building, the mass of water vapor and other gases inside the compartments and pipes, the water vapor on the surface of the building bodies, the water vapor and other gases in the solid matrix of opaque and inner bodies, the relative humidity of the air inside the compartments, the air velocity and the mean radiant temperature inside the compartments.

The university school building analyzed in this work, with three floors and 110 spaces, 122 transparent bodies (windows) and 1516 opaque bodies (interior and exterior walls, floors, roof and doors). The study is carried out both in summer and winter conditions, and the cycle of occupation and the air renewal rate are considered. The heating, ventilation and air conditioning work only when there are occupants in the compartments.