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# Urban Green Infrastructure Planning as a Contribution to the Smart "Green" City

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## 1 ABSTRACT

The urban green infrastructure is getting due to the strong growth of the City of Vienna under increasing pressure. A foresighted planning of green and open spaces is necessary to obtain the different "Ecosytem Services" - provision-related services, regulatory services, cultural services and support services (MEA 2005). Additionally an increase in the number of hot days and thus an increase of the heat load in the city is predicted for Vienna (ZAMG 2012). Again, making a foresighted planning of green and open spaces is a significant contribution to meet these climatic challenges (Kuffner A. 2012, Hagen et al. 2010). Based on the concept of "green infrastructure" (Pauleit et al. 2011) and the ecosystem services of these, it is shown which contribution - in particular to reduce the heating of the city - they can make to the Smart City concept.

## 2 DEFINING A SMART CITY

The City of Vienna has successfully positioned itself in the international competition of cities as a Smart City (first place under „The Top 10 Smart Cities on the Planet 2011", Number 3 of the "10 Smartest Cities in Europe 2013").This includes in particular the combination of urban density with a high quality of life (first Place in this ranking and in the Mercer 2012 study). Cities have to become smarter to overcome actual challenges such as climate chnge. Many actors from different disciplines tried to define or answer the question: What makes a City to a smart City? There exist many definitions of Smart City. The aim of the paper is to look at the Smart City concept from a "green point of view" on the example of the urban heat island effect. The article outlines how the planning of urban green infrastructure contributes to the Smart City concept.

### 2.1 Smart City – the new Sustainable City?

The idea behind "Smart City" is that by using innovations and technologies resources can be used efficiently. The term has a technological background and origin. Recently more and more aspects and spheres of activity are subsumed under the term Smart City. Quality of live is the aim, which is found within most Smart City strategies. Technology is just a part of the strategy.


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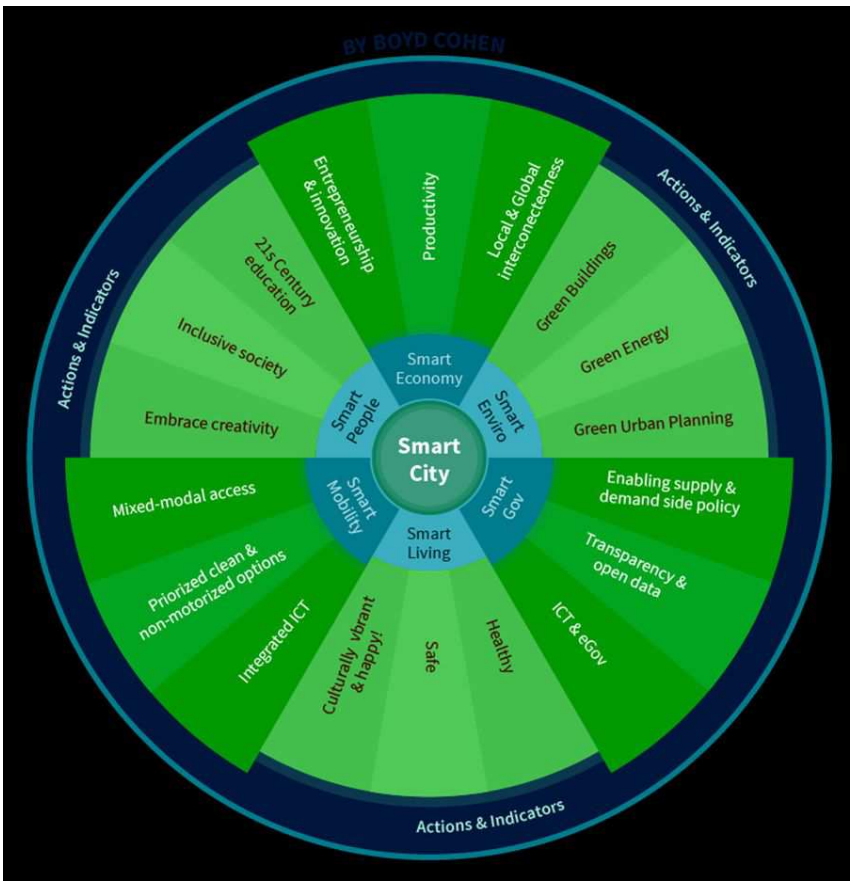


Fig. 1: Basic Smart City Indicators (Source: http://www.boydcohen.com/smartcities.html)

Boyd Cohen uses six smart categories - People, Mobility, Living, Government, Economy and Environment - for an international ranking of Smart Cities. This typology has also been used by Giffinger since 2007. According to his approach a Smart City includes not only smart technologies but also smart residents, smart mobility, smart economy, smart housing, smart management and the smart environment (Giffinger R. 2007).

Also the European Union is using these categories (GD IP 2014). A city could be classified as a Smart City if they have at least one initiative which addresses at least one of the above mentioned topics – using ICT. Their working definition of a Smart City is: "As a result, this study's working definition of a Smart City is 'a city seeking to address public issues via ICT-based solutions on the basis of a multistakeholder, municipally based partnership" (GD IP 2014: 24). They also made an overview of different definitions of what a Smart City is. The spectrum is broad. They also see overlaps of the Smart City concept with other concepts such as "'Intelligent City', 'Knowledge City', 'Sustainable City', 'Talented City', 'Wired City', 'Digital City' 'Eco-City'" (ibid. 22). Also natural resources and the smart handling of these is often part of the definition of a Smart City.

They also define six Smart City characteristics. For the focus of the paper – the urban green infrastructure and the link to the Smart City concept – the definition of the "Smart Environment" is most relevant: "By smart environment we include smart energy including renewables, ICT enabled energy grids, metering, pollution control and monitoring, renovation of buildings and amenities, green buildings, green urban planning, as well as resource use efficiency, re-use and resource substitution which serves the above goals. Urban services such as street lighting, waste management, drainage systems, and water resource systems that are monitored to evaluate the system, reduce pollution and improve water quality are also good examples" (ibid. 28). A combination of measures regarding climate change adaption and mitigation, ICT, energy efficiency and urban ecology are mixed and merged within this category. So urban green infrastructure planning as a mean to counteract UHI effects should be a contribution to the Smart City concept.

Let us have at last a look on the Viennese definition and understanding of a Smart City. Climate change and shortage of resources are the first topics which are mentioned looking at the "Smart City Homepage" (smartcity.wien.at). A Smart City is "a city that is fit for the future and geared towards opportunities and that is capable of producing credible perspectives for its people" (smartcity.wien.at). The aim is to improve the

ecological, economic and social performance. Also the strong growth of the City of Vienna is mentioned which is a driving factor for rising energy consumption. Within six categories different projects are summarized which are making Vienna a Smart City (Education & Research, Building Activity & Living, Transportation & Urban Planning, Environment & Climate Protection, People & Society, Politics & Administration). Building projects, city development projects but also strategies like the new City Development Plan (STEP 2025) are mentioned.

This short overview of criteria, which define Smart Cities, shows that they are manifold and different within the cities. Going back to the categories of Boyd Cohen, the aspect "Smart Environment" covers three categories: green buildings, green energy and green urban planning. Let us see if and which aspects urban green infrastructure planning can contribute to the Smart City concept.

## 3 UHI AND URBAN GREEN INFRASTRUCTURE

The urban heat island effect is one of the challenges cities are facing due to the strong growth of the cities and the climate change. The urban green infrastructure is getting under increasing pressure due to the strong growth of the City of Vienna – the latest data from Statistics Austria predict a rise up to two million people in the years 2030-2035 – Additionally, an increase of hot days and thus an increase of the heat load in the city is predicted for Vienna (ZAMG 2012).

These two factors are the driving forces for an increase of the so called urban heat island effect. The urban heat island describes the effect of the temperature differences of urban and rural areas. The UHI effect is not a new phenomenon. It has been known since the 19th century (Howard 1820). Over the past few years, summer heat waves occurred more often throughout Europe and an increased attention in the European media was noticeable (Allex et al. 2011). Usually, the intensity of this difference is about 1 to 3 degrees kelvin, but can rise up to 12 degrees kelvin (Kiesel et. al 2014). It depends of course on the local climate and the spatial situation of a city. But the UHI effect is triggered by dense building and high degree of soil sealing. That means the loss of urban green infrastructure which supports the mitigation of the UHI effect throughout evapotranspiration (and shading) leads to higher temperatures within the City. A foresighted planning of green and open spaces is necessary to obtain not only the different "Ecosytem Services" – provision-related services, cultural services and support services (MEA 2005) – but especially the "regulatory services" of urban green infrastructure. The City of Vienna therefore takes part in a European wide project to reduce the UHI effect. The article is based on the experiences and results of the project "Urban Heat Islands – Strategy Plan Vienna" which is part of the international CE (Central Europe) project "Urban Heat Islands – Development and application of mitigation and adaptation strategies and measures for counteracting the global Urban Heat Islands phenomenon" (duration 2011-2014). The aim of the project "Urban Heat Islands – Strategy Plan Vienna" is the identification of measures to reduce the negative aspects of urban warming and evaluate the different steering and control levels to implement measures.

### 3.1 Measures to reduce UHI effects

Measures to reduce the UHI effect could roughly be separated in strategic approaches and city scale planning measures as well as concrete technical and building measures. A third category is public relation and information measures – which is not the focus of the UHI project. Throughout a comprehensive literature research a broad spectrum of measures counteracting the UHI effect were selected and analyzed by a simplified SWAT analysis (Strengths, Weaknesses, Opportunities and Threats) (e.g. Terrados et.al., 2005). Additionally the effectiveness of the measures were analyzed using different categories – influence on meso-climate, micro-climate, biodiversity, quality of life, economical aspects like building and maintaining costs, feasibility and acceptance by different stakeholder groups (e.g. politicians, administration, developer…). The analysis showed that only green urban infrastructure and with some restriction blue urban infrastructure have effects at least on the micro climate. They reduce the heat impact throughout evapotranspiration and especially the planting of trees also provides shading. The "smart" solutions and technologies which were developed –for example the active and passive cooling of buildings, smart meters to monitor the energy consumption – are influencing the wellbeing of the people, but do not have an effect on the micro and meso-clima. In case these systems use air conditions they are worsening the situation in the urban fabric because they emit additional heat (anthropogenic heat) and need energy. In an iterative process with scientific experts and in close cooperation with the responsible city administration departments mostly measures within the

urban green infrastructure were selected to be part of the "Urban Heat Island Strategy Plan of the City of Vienna". The measures are reaching from the conserving and maintaining of fresh air corridors (green corridors) over additional green spaces down to the intensified planting of trees within the street canyons.

### 3.2 Urban green infrastructure and ecosystem services

Urban green infrastructures (UGI) are providing a lot of different so called "ecosystem services" (Parlow 2011). The urban areas and the inhabitants benefit ecologically, socially and economically from UGI. They provide provision-related services, regulatory services, cultural services and support services (MEA 2005, Colding 2011).The influence on the urban climate is – together with other mitigating effect on various incidents and catastrophes like heavy rain or floods – a regulatory service (Gomez-Baggethun et al. 2012). Due to the other ecosystem services of urban green infrastructure measures in this sector are very efficient, because they show synergies with other urban planning strategies such as the increase of biodiversity. The ecosystem approach is discussed since the 1990ies and the services provided are crucial for the quality of life of a city (Colding 2011). Important within this approach is, that urban green infrastructure has the same value and significance like other urban infrastructure (e.g. water supply and management or the traffic system) (Pauleit et al. 2011). Urban green infrastructure like other infrastructures has to be handled on different levels – from green corridors which support City wide the air circulation and ventilation down to a tree which provides shading (STEP 2005, Hagen et al. 2010, Proksch et al. 2011). That implies that the implementation of urban green infrastructure has to occur on different spatial layers.

### 3.3 Urban green infrastructure planning, a longitudinal and cross-sectional topic

Another focus of the UHI project is the analysis of different planning levels, tools and instruments. As the planning of urban green infrastructure needs a mulit-scalar and multi- disciplinary approach a lot of different planning levels and stakeholders are involved (Reinwald et. al 2013). Legally binding instruments, master plans and urban development concepts and – what is new for the City of Vienna – also on the basis of private-law contracts are the tools to implement the strategies. Between these planning instruments a balance between the (partly competing) aims of the urban development of the City of Vienna has to be accomplished.

Green spaces have to fulfill more requirements and have to accommodate more functions than they used to. A lot of different measures and projects were developed and implemented regarding city development approaches such as the Smart City, Energy Efficient City, Ecological City etc. These are for example the increase of the energy efficiency or the production of renewable energy. Some of them are mutually exclusive – for example the use of a flat roof for roof greening to reduce the UHI effect or to produce energy by using solar panels. Additionally facilities for example the use of geothermal energy or wind power need space, changes the airflow etc. That means a lot of counteracting aims have to be balanced.

Making a foresighted planning of urban green infrastructure is a significant contribution to meet the different needs (Kuffner A. 2012, Hagen et al. 2010). Not only different planning levels are concerned, but also different types of urban green infrastructure – public, institutional, and private – have to be taken into account. According to the many different stakeholders involved a communicative planning process is needed (Healey 2007) – an aspect which is also mentioned within the Smart City Concepts.

Additionally the implementation of the measures has different time horizons. Short-term preventive measures such as heat warning systems and information campaigns – how to behave during heat periods – can be implemented fast. Also technical measures for example a sun screens for windows can be implemented within a reasonable time frame. On the other hand, large-scale strategic measures to increase the amount of urban green areas take a long time.

## 4 URBAN GREEN INFRASTRUCTURE AND THEIR CONTRIBUTION TO THE SMART CITY CONCEPT

Coming back to Boyd Cohans "Smart City Wheel" the starting point of the paper and the search for the link of urban green infrastructure and Smart Cities: One (the only one) indicator for the "working are" sustainable urban planning within the "smart dimension" environment is the urban green open areas per capita in square meters – an easy to use indicator, with low significance. The City of Vienna has approximately 50% green spaces. If you divide this area by the number of inhabitants everybody has 120 square meter green spaces (http://www.wieninternational.at/de/content/umweltstadt-wien-5050-gruen-de). But this number does not

take the distribution, the type of green infrastructure or the area which is selected for the calculation into account. The amount of green areas which could for example mitigate the UHI effect or support renewable enrgy production depends on the type of urban fabric. An evaluation from City of Vienna showed, that the amount differs within the inner city districts between 5,8 up to 25 square meters (ÖBIG 2002: 15). So this number does not really tells us something about the "smartness" of a City. But it indicates that green infrastructure contributes to the Smart City concept. Effort should be set on the indicators selected to incorporate the manifold ecosystem services which are provided by urban green infrastructure.

The point is not to forget on the urban green infrastructure while developing a Smart City. Urban green infrastructure – as shown on the example of the urban heat island phenomenon – can provide solutions for the future city nevertheless green infrastructure is mostly (with some exceptions like green facades or green roofs) "low-tech" and therefore not recognized as "smart". The urban green infrastructure approach – to see green structures equivalent to other "smart" infrastructures within a city – can help to fulfill this task.

## 5 REFERENCES


Allex, B., Liebl, U., Brandenburg, C., Gerersdorfer, T., Czachs, C. (2011). "Hot Town, Summer in the City". The challenges posed by increased hot days on urban tourism, Management Letter, Tourism Service department at the Austrian Federal Ministry of Economy, F 652 amily and Youth. Vienna. (German)

Colding J. (2011). The Role of Ecosystem Services in Contemporary Urban Planning. Urban ecology: patterns, processes and applications. J. Niemala, ed., New York: Oxford University Press. 219-227

Giffinger R. (2007): Smart cities, Ranking of European medium-sized cities; http://www.smart-cities.eu/press-ressources.html

GD IP Directorate-General for Internal Policies (2014): Mapping Smart Cities in the EU

Gómez-Baggethun, E., Barton, D.N., (2013). Classifying and valuing ecosystem services for urban planning. Ecol. Econ. 86, 235–245.

Hagen K., Stiles R., Trimmel H. (2010): Wirkungszusammenhänge Freiraum und Mikroklima, Ed. Bundesministerium für Verkehr, Innovation und Technologie

Healey, P. (2010): Making Better Places: The Planning Project in the Twenty-First Century. Palgrave Macmillan. Basingstoke.

Howard, L., (1820). The Climate of London. Deduced from Meteorological Observations Made at Different Places in the Neighbourhood of the Metropolis. In Two Volumes.

W.Phillips.

Kiesel T., Vuckovic M. Mahdavi A. (2014): A structured path tot he assesment and evaluation oft he urban microclimate in Central Europe, UHI Newsletter Nr. 3

Kuffner A. (2012): Den Stadtorgaismus schlank, kühl und sauber halten, In: Widmann H. (Ed.): Smart City, Wiener Know-How aus Wissenschaft und Forschung, Schmid Verlag, Wien

MEA – Millennium Ecosystem Assessment (2005): Ecosystems and Human Well-being: Synthesis. Island Press, Washington, DC. Online im Internet: http://www.millenniumassessment.org/documents/document.356.aspx.pdf, Zugriff: 23.04.2013.

Mercer-Studie 2012: http://www.mercer.com/articles/quality-of-living-survey-report-2011

ÖBIG (2002): Biotopmonitoring Wien

Parlow, E. (2011). Urban Climate. Urban ecology: patterns, processes and applications. J. Niemala, ed., New York: Oxford University Press, 31-44

Pauleit, S., Liu, L., Ahern, J., Kazmierczak, A. (2011): Multifunctional Green Infrastructure Planning to Promote Ecological Services in Cities. In: Niemala, J. (ed.). Urban ecology: patterns, processes and applications. New York: Oxford University Press.

Proksch T., Cermak P., Janetsch-Borst A. Stadler K. (2011). FREI.RAUM.NETZ WIEN –Erstellung und Definition eines Freiraum – Hauptnetzes für Wien, MA 18 Stadtentwicklung und Stadtplanung – Landschafts- und Freiraumplanung (Ed.)

Reinwald et. al (2013): Urban Heat Islands – Strategy Plan Vienna

Scheuvens R., Tschirk W., Krassnitzer P. (2010): Planung als Prozess, Gestaltung dialogorientierter Planungs- und Umsetzungsprozesse, MA 21B Editor, Werkstattbericht Nr. 109

Step (2005). City Development Plan Vienna 2005. Vienna

The Top 10 Smart Cities on the Planet 2011: http://www.fastcoexist.com/1679127/the-top-10-smart-cities-on-the-planet

Terrados, J., Almonacid, G., Hontoria, L. (2005). Regional energy planning through SWOT analysis and strategic planning tools. Impact on renewables development. Renewable and Sustainable Energy Reviews 11 (2007), 1275–1287.

ZAMG (2012): http://www.zamg.ac.at/cms/de/klima/news/hitzetage-werden-immer-haeufiger; accessed on 19.02.2013.



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