

Planning Support System Development for analysing environmental performance of form-based design decisions: Case Study of Enschede

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Abstract

The environmental performance of urban neighbourhoods is a crucial indicator to measure the sustainability of the built urban form, especially as cities face increased urbanisation and densified development. With new construction contributing significantly to global carbon emissions, there is a need to understand how modifications in the urban form can affect its environmental performance at the scale of the neighbourhood. This research addresses this need by developing a Planning Support System workflow to aid decision-making in urban planning in order to analyse environmental performance, focusing on thermal comfort and solar energy potential. It explores the relationship between urban form and the selected environmental performance indicators while utilising freely available 3D geoinformation data of the Netherlands. It develops simplified workflows using established plug-ins and open-source 3D software that can be replicated by smaller municipalities with resource constraints, thus removing barriers to 3D-data based data-driven decision making for sustainable and informed urban planning.

1. Introduction

The built form of urban area significantly affects the environmental performance at the scale of the neighbourhood (Mussawar et al., 2023). Given that construction contributes approximately 40% of the total global carbon emissions, and urbanisation and densification of cities continue unabated, it is necessary to understand the impact of urban form-based decisions on its environmental performance (van Oosterom, 2022). As the scale of action shifts from policy at global level to action at a local level, municipalities are now obliged to create action plans within the realms of the national and international policy (Salter et al., 2020). Acknowledging the critical role of early-stage decision-making in influencing urban form (Méndez Echenagucia et al., 2015), there is a requirement for a Planning Support System workflow that facilitates informed decision-making in planning projects with the objective of analysing environmental performance, as a contribution to sustainability at a local scale.

To derive comprehensive insights into the environmental performance of neighbourhood-scale projects, a 3D perspective is important as buildings exist under the influence of their surroundings. It enables understanding spatial relations from a volumetric viewpoint, highlighting the influence of morphology in immediate surroundings. Thus, this research intends to make use of the freely available 3D geoinformation of the Netherlands to model existing and future scenarios to examine to what extent does change in urban form effect the environmental performance of a neighbourhood.

The environmental performance of buildings and neighbourhoods together contribute to urban liveability as the immediate outdoors are seen as an extension of the living space (Lau et al., 2018). As the research delves into the components and contributors to environmental performance and its measurement, it is crucial to clarify the terminology. Indicators describe the state of the environment and are used to assess performance (European Environment Agency, n.d.). They are often made of a combination of parameters and serve as an estimate of a system, such as PET (thermal comfort indicator) or

Solar Potential estimate derived from solar irradiation (in kWh/m²). Variables are any modifiable factors within a system, such as building orientation, or roof area. They may be dependent or independent in nature and can be measurable or qualitative. Parameters are measurable variables, such air temperature, or percentage of shadowing of roof surfaces.

While multiple performance indicators exist, such as thermal performance, energy consumption, greenery, daylighting, carbon emissions etc, in the context of this research, environmental performance is narrowed down to two performance indicators – the indicator of thermal comfort due to urban built form (estimated using Physiological Equivalent Temperature) and the indicator of solar rooftop energy harvest (using pixel-based Solar Energy Potential suitability analysis). These are selected as both indicators are very dependent on location and morphology and have differing morphological requirements for improvement – as is illustrated further in Table 1.

UHI	Source	Solar Potential	Source
Average building height: street width ratio - urban canyon	(Deng and Wong, 2020; Nasrollahi et al., 2021; Siu et al., 2021)	Available roof area (not too small, without major obstructions)	(Li-Lian, 2022)
Shadowing from neighboring buildings - height ratio between adjacent buildings	(Nasrollahi et al., 2021; Siu et al., 2021)	Shadowing from neighboring buildings - height ratio between adjacent buildings	(Bardhan et al., 2020; Li-Lian, 2022)
Building orientation - long side towards south	(Nakata-Osaki et al., 2018)	Roof angle/orientation - long side towards south	(Bardhan et al., 2020; Li-Lian, 2022)

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Environmental Performance of Coal-fired FBC Mitsuru Takeshita, 1994 *Advances in the Science of Victorian Brown Coal* Chun - Zhu Li, 2004-10-21 Over the past decade extensive research has been conducted on the subject of coal as one of the world's leading energy sources. The current and future status of this resource is a topic of considerable interest to the largest world economies including the US, Japan, China, and Europe. *Advances in the Science of Victorian Brown Coal* provides critical reviews of the information and research published over this time, giving the reader an authoritative overview of the science surrounding this important topic. Critical review of recent research surrounding the utilization of brown coal. Key issues addressed include maximized efficiency and minimized environmental impacts. Focuses on Victorian Brown Coal within the context of biomass and bituminous coal. A critical thermodynamic overview of various advanced power generation technologies. **Proceedings of the 20th International Conference on Fluidized Bed Combustion** Guangxi Yue, Hai Zhang, Changsui Zhao, Zhongyang Luo, 2010-07-28 The proceedings of the 20th International Conference on Fluidized Bed Combustion (FBC) collect 9 plenary lectures and 175 peer-reviewed technical papers presented in the conference held in Xi'an, China, in May 18-21, 2009. The conference was the 20th in a series covering the latest fundamental research results as well as the application experience from pilot plants, demonstrations, and industrial units regarding to the FBC science and technology. It was co-hosted by Tsinghua University, Southeast University, Zhejiang University, China Electricity Council, and Chinese Machinery Industry Federation. A particular feature of the proceedings is the balance between the papers submitted by experts from industry and the papers submitted by academic researchers aiming to bring academic knowledge to application as well as to define new areas for research. The authors of the proceedings are the most active researchers, technology developers, experienced and representative facility operators, and manufacturers. They presented the latest research results, state-of-the-art development and projects, and the useful experience. The proceedings are divided into following sections: CFB Boiler Technology, Operation and Design, Fundamental Research on Fluidization and Fluidized Combustion, CO₂ Capture and Chemical Looping, Gasification, Modeling and Simulation on FBC Technology, Environments and Pollutant Control, Sustainable Fuels. The proceedings can be served as idea references for researchers, engineers, academia, and graduate students, plant operators, boiler manufacturers, component suppliers, and technical managers who work on FBC fundamental research, technology development, and industrial application. Characterization of Porous Solids VI, 2002-11-14 This book contains 99 of the papers that were presented at the 6th in the series of Symposia on Characterization of Porous Solids held in Alicante, Spain, May 2002. Written by leading international specialists in the subject, the contributions represent an up-to-date and authoritative account of recent developments around the world in the major methods used to characterize porous solids. The book is a useful work of reference for anyone interested in characterizing porous solids such as MCM-41, mesoporous materials, pillared clays, etc. Papers on pore structure determination using gas adsorption feature

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Fundamentals and Technology of Combustion F El-Mahallawy,S. E-Din Habik,2002-07-10 Fundamentals and Technology of Combustion contains brief descriptions of combustion fundamental processes followed by an extensive survey of the combustion research technology It also includes mathematical combustion modeling of the processes covering mainly premixed and diffusion flames where many chemical and physical processes compete in complex ways for both laminar and turbulent flows The combustion chemistry models that validate experimental data for different fuels are sufficiently accurate to allow confident predictions of the flame characteristics This illustrates a unique bridge between combustion fundamentals and combustion technology which provides a valuable technical reference for many engineers and scientists Moreover the book gives the reader sufficient background of basic engineering sciences such as chemistry thermodynamics heat transfer and fluid mechanics The combustion research and mathematical models fit between small scale laboratory burner flames and large scale industrial boilers furnaces and combustion chambers The materials have been collected from previous relevant research and some selected papers of the authors and co workers which have been presented mainly in different refereed journals international conferences and symposia thus providing a comprehensive collection Furthermore the book includes some of the many recent general correlations for the characteristics of laminar turbulent premixed and diffusion flames in an easily usable form The authors believe that further progress in optimizing combustion performance and reducing polluting emissions can only be treated through understanding of combustion chemistry **Pressurized Fluidized Bed Combustion** M. Alvarez Cuenca,E.J. Anthony,2012-12-06 Pressurized fluidized bed combustion PFBC is one of the newest of the coal based generation technologies available commercially This authoritative volume contains an excellent balance of the

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U.S. Electric Power System Reliability United States. Congress. House. Committee on Science and Technology. Subcommittee on Energy Development and Applications,1982 **Proceedings of the 18th International Conference on Fluidized Bed Combustion--2005** ,2005 Energy, Resources and Environment S.W. Yuan,2013-10-22 Energy Resources and Environment documents the first U S China Conference and discusses the concerns about the world s energy situation such as its resource environmental effects and possible alternative sources The book is comprised of 72 chapters including the keynote address five lecture papers and 66 technical papers that are organized according to its contents specifically the type of energy it discusses The text begins with the keynote address and then discusses the plenary and technical papers The plenary papers discuss the importance of energy resources environment and future development The technical papers cover the technological advancement of alternative energy source and their application The conference covers the following theme chemical fuels coal energy electric power systems energy conservation geothermal and other natural energy hydropower ice storage for cooling solar energy wind energy economic aspect of energy utilization and impact of energy on the environment The book will be of great interest to individuals concerned with the development of alternative energy sources Researchers whose work involves alternative energy will be able to make use of this book as a reference material **Energy Abstracts for Policy Analysis** ,1982 Tidd: The Nation's First PFBC Combined-Cycle Demonstration , *Acid Precipitation* ,1988

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