

Towards more comprehensive urban environmental assessments

Exploring the complex relationship between urban and metabolic profiles

Aristide Athanassiadis



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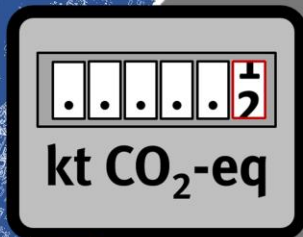


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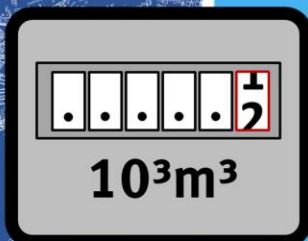
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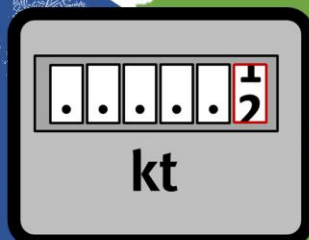
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Towards more comprehensive urban environmental assessments

**Exploring the complex relationship between urban and
metabolic profiles**

Aristide Athanassiadis

Submitted in total fulfilment of the requirements of the degree of Doctor of Philosophy
under a jointly-awarded PhD program with the Université Libre de Bruxelles and the
University of Melbourne

June 2016

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Declaration

This is to certify that:

- the thesis comprises only my original work towards the PhD (a list of publications resulting from this work is presented here below),
- due acknowledgement has been made in the text to all other material used,
- the thesis is fewer than 100,000 words in length, exclusive of tables, maps, bibliographies and appendices.

Signed

A handwritten signature in black ink, consisting of a series of loops and a long horizontal stroke extending to the right.

Aristide Athanassiadis

Date 22/06/2016

Abstract

Urban areas cover 2% of the Earth's land surface, host more than 50% of global population and are estimated to account for around 75% of CO₂ emissions from global energy use. In order to mitigate existing and future direct and indirect environmental pressures resulting from urban resource use, it is necessary to investigate and better understand resource and pollution flows associated with urban systems.

Current urban environmental assessment methodologies enable the quantification of resource use and pollution emissions flows entering, becoming stocked and exiting urban areas. While these methodologies enable to estimate the environmental effect of cities, they often consider urban areas as being static and homogeneous systems. This partial and simplistic representation shadows the complex spatio-temporal interrelationships between the local context and its associated local and global environmental pressures. This characterisation of urban systems is a significant limitation, not only for the urban environmental assessments, but also for the identification of their drivers as it may lead to inadequate urban environmental policies. To overcome this limitation and effectively reduce *glocal* urban environmental pressures, it is necessary to better understand the complex functioning of cities and identify their drivers.

This research developed a comprehensive urban environmental assessment framework that helps to better explicit and understand the complex relationship between an urban system and its environmental profile in a systemic and systematic way. This framework was applied to the case study of Brussels Capital Region (BCR).

Results from the application of this framework show that urban systems are neither static nor homogeneous. In fact, different relationships between the urban and metabolic profiles appear when considering different spatial scales and temporal intervals as well as different urban and metabolic metrics. The establishment of BCR's urban profile showed that components that shape the urban system evolve in an organic way over time. Moreover, the spatial expression of an urban system portrays its heterogeneous aspect and how different metrics of the same urban indicator can reveal distinct facets and challenges for an urban area or a neighbourhood. Finally, it was demonstrated that the relationship between urban indicators is different for each spatial scale and therefore knowledge from one spatial scale is not necessarily transferable from one scale to another. The establishment and analysis of BCR's metabolic profile also underlined the complex functioning of cities as each flow has a different temporal evolution and spatial expression. Due to the multifaceted and intertwined aspect of metabolic flows it becomes clear that no single parameter enables to explain or predict their behaviour.

This leads to the conclusion that a great number of questions still need to be considered, understood and answered before effectively and coherently reducing

environmental pressures from cities. The developed framework proposes a number of concrete steps that enable existing and new cities to better understand their metabolic functioning and ultimately transition towards less environmentally harmful futures.

Publications resulting from work reported in this thesis

Refereed journal papers

- 1) Athanassiadis, A., Bouillard, P., Crawford, R.H., Khan, A.Z., (in press). Towards a dynamic approach to urban metabolism: tracing the temporal evolution of Brussels' urban metabolism from 1970 to 2010. *Journal of Industrial Ecology*.
- 2) Athanassiadis, A., Christis, M., Bouillard, P., Crawford, R.H., Khan, A.Z., Vercauteren, A., (accepted with revisions). Comparing a metabolism-based and an input-based approach to assess local and global environmental performance of a city. *Journal of Cleaner Production*.
- 3) Athanassiadis, A., Bouillard, P., Crawford, R.H., Khan, A.Z., (under revision). L'écosystème urbain de Bruxelles: Passé, présent, futur. *Brussels Studies*.

Refereed conference papers

- 1) Athanassiadis, A., Fernandez, G., Hoekman, P. (under revision). Comparing the urban metabolism of Brussels, Cape Town and Milan: A discussion on data collection and analysis. Proceedings of ISOCARP 2016, Cities we have vs. Cities we need, 12-16 September, Durban.
- 2) Bettignies, Y., Athanassiadis, A., Galán González, A., González Gomez, M. (2016). Toward Resilient Cities: Brussels Capital Region Case Study. Proceedings of PLEA 2016, Cities, Buildings, People: Towards Regenerative Environments, 11-13 July, Los Angeles (under revision).
- 3) Athanassiadis, A. P. Bouillard, R. H. Crawford (2015). Exploring the relation between Melbourne's water metabolism and urban characteristics. Proceedings of SOAC 2015, State of Australian Cities Conference. 9-11 December, Gold Coast.
- 4) Athanassiadis, P. Bouillard, R. H. Crawford (2015). Overcoming the 'black box' approach of urban metabolism. Proceedings of ASA 2015, Living and Learning: Research for a Better Built Environment. 4-6 December 2015, University of Melbourne.
- 5) Galán González, Q. Deltenre, A. Athanassiadis, A. Evrard, S. Trachte, Ph. Bouillard, A. C. Acha Roman (2015). Preserving Brussels identity: Methodological guidelines for the retrofitting of city blocks. Proceedings of CISBAT 2015, Cleantech for Smart Cities & Building from Nano to Urban Scale, 9-11 September 2015 EPFL-Lausanne
- 6) S. Trachte, A. Galán González, A. Evrard, A. Athanassiadis (2015). B³-Retrottool: Development of a multi-scale and multi-criteria pre-assessment tool for the sustainable retrofit of Brussels Capital Region. 2ème Congrès Interdisciplinaire du Développement Durable, 20-22 Mai 2015. Université Catholique de Louvain.

- 7) **S. Trachte, A. Evrard, A. Galán González, A. Athanassiadis (2014).** Sustainable retrofit of the old part of dwellings stock in Brussels Capital Region. Proceedings of PLEA 2014, Sustainable habitat for developing societies, 16-18 December, Ahmedabad
- 8) **Galán González, A. Athanassiadis, A. Evrard, S. Trachte, Ph. Bouillard, A. De Herde (2014).** OLD BUILDINGS, NEW CITIES: Energy renovation strategies for the historic residential stock of Brussels. Proceedings of WSB 2014, World Sustainable Building Conference, 28-30 October 2014 Barcelona
- 9) **Athanassiadis, A. Galán González, A. Evrard, S. Trachte, Ph. Bouillard, A. De Herde (2014).** Assessing the energy use of the pre-war residential stock of Brussels Capital Region at a neighbourhood scale. Proceedings of WSB 2014, World Sustainable Building Conference, 28-30 October 2014 Barcelona
- 10) **Athanassiadis A. and Bouillard P. (2013).** Contextualizing the Urban Metabolism of Brussels: Correlation of resource use with local factors. Proceedings of CISBAT 2013, Cleantech for Smart Cities & Building from Nano to Urban Scale, 4-6 September 2013 EPFL-Lausanne

Refereed conference abstracts

- 1) **Stephan, A., Athanassiadis, A. (2016).** Mapping the material stock of City of Melbourne's buildings using a bottom-up approach and open data. Proceedings of ISIE 2016, International Society for Industrial Ecology (SEM) section Conference, 28-30 September. Nagoya, Japan.
- 2) **Athanassiadis, A., M. Christis, P. Bouillard, R. H. Crawford, A. Vercalsteren (2015).** Comparing an Urban Metabolism-based and an Input-Output-based approach. Assessing direct and indirect resource use and environmental impacts at the city level: The case of Brussels, Belgium. Proceedings of ISIE 2015, International Society for Industrial Ecology Conference, 7-10 July. Surrey, UK.
- 3) **Athanassiadis A, Ph. Bouillard, A. Z. Khan, R. H. Crawford (2014).** Towards a more complex Urban Metabolism: the case of Brussels. Poster presented in GRC Conference on Industrial Ecology: Transforming the Industrial Metabolism, 1-6 June 2013 Lucca
- 4) **Athanassiadis A, Ph. Bouillard (2013).** "Multi-scale analysis of energy and material urban flows as a methodological tool for urban planning and territorial ecology" at the poster session: "*What transversal approaches to integrate sustainable development in research*" organised by Higher Education & Research Awards for future generations

Scientific reports

- 1) **Athanassiadis, A., Merckx, B., Noel, L., Paolini, F., (2015).** Métabolisme de la Région de Bruxelles-Capitale: identification des flux, acteurs et activités économiques sur le territoire et pistes de réflexion pour l'optimisation des ressources. Institut Bruxellois de Gestion d'Environnement, Brussels, p. 305.
- 2) **Athanassiadis, A. (2014).** Représentations et Visions Ecosystémiques de Bruxelles. Vulgarisation book about urban ecosystems in the framework of the Paul Duvigneaud Award, p. 56.
- 3) **Athanassiadis, A. (2013).** Evaluation of the Urban Metabolism: Urban Metabolism scope and purpose definition, p. 23.
- 4) **Athanassiadis, A. (2013).** Evaluation of the Urban Metabolism: Data repository and neighbourhood metabolism, p. 30.

Acknowledgements

I would like to take this opportunity to thank all the people that contributed to my personal and scientific development over these last four years. Firstly, I would like to thank Philippe Bouillard for offering me a research internship in 2012 that opened the doors to this research, empowering me from the early stages of this PhD, and enabling me to explore my own path. I would also like to thank Robert Crawford for making my research stay in Melbourne possible, helping me finish this thesis on time, as well as ensuring its quality. This research stay undoubtedly helped me make this thesis more comprehensive. Finally, I would like to thank Ahmed Khan for involving me in the development of research projects, as well as for his follow-up on this research.

I would also like to thank a great number of people for their direct and/or indirect help into making this thesis possible. Unfortunately, I am certain that by making a list, I would not include all of them due to my faulty memory. Taking this into account, I would still like to thank Rika Devos, Jacques Teller, Jack Barton and Greg Foliente for their guidance, Sabine Barles and Paulo Ferrão for their valuable comments and a great number of stakeholders that provided me valuable data and insights through interviews (the list is very long) but also a number of people with which I collaborated during this research (the list is also long but I would still like to thank André Stephan, Arancha Galán González, Sophie Trachte, Arnaud Evrard, Bertrand Merckx, Louise Noel, Federica Paolini, Juliette de Villers, Véronique Verbeke, Marion Courtois, Catherine Vanderstichelen, Maarten Christis, An Vercalsteren, Olivier Decocq, Luis Pôlet, Farass El Haddoutti, Nadia Casabella, Dimitris Panayotopoulos, Miriam Ram and Olv Klijn, Ben Kubbinga, Paul Hoekman, Gabriela Fernandez and would like to apologise for the many others I forgot).

This research would also have been impossible without my colleagues in Brussels and Melbourne helping me to stay curious, but also the administrative staff that helped me to overcome the administrative difficulties of a joint-PhD.

I would like to like to thank my friends, family and Caroline for helping me juggle between personal and research life. Without them, I would not have been able to finish this research sane.

Finally, I am very grateful to the financial support of the Fonds de la Recherche Scientifique (F.R.S. - FNRS), Wallonie-Bruxelles International (WBI) and the Université Libre de Bruxelles that enabled me to completely focus on my research, but also to make my stay in Melbourne and my attendance in conferences possible.

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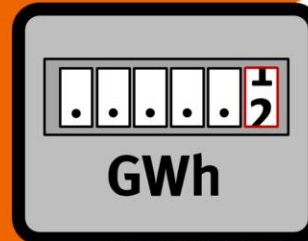
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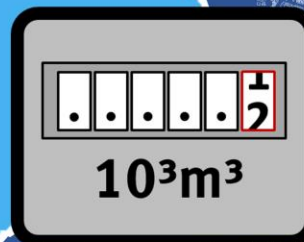
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ENERGY



WATER



MATERIALS IN

