Decision making on indoor climate control in historic buildings: knowledge, uncertainty and the science-practice gap

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Academic dissertation in Conservation, to be publicly defended, by due permission of the Faculty of Science at the University of Gothenburg, on 3 October 2016 1 P.M. at the Department of Conservation, the Auditorium, Geovetarcentrum, Guldhedsgatan 5c, Gothenburg.

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Abstract
Balancing use, preservation and energy use is a fundamental challenge for the whole heritage field. This is put to the point in designing and operating systems for indoor climate control in historic buildings, where competing objectives such as preservation, comfort, accessibility, energy use and cost have to be negotiated in the individual case.

The overarching aim of this thesis is to explore the gap between research and practice regarding energy efficient indoor climate control in historic buildings. The thesis deals with historic buildings where both the building fabric and the movable collection are vulnerable and where the management of the building is more or less professionalized. Examples of such buildings are palaces, churches and historic house museums, ranging from the large and complex to the small and simple. A key to a more sustainable management of these buildings is to understand how scientific knowledge related to indoor climate control can become usable for the professional practitioner.

The thesis comprises six published papers introduced by a thesis essay. The papers reflect a progression both in terms of the research questions and the methodology. The first three papers outline the background needed for a technical understanding of the involved matters through an identification of key knowledge gaps. The three remaining papers use qualitative case studies to understand the nature of the gap between science and practice by paying more attention to the social aspects of decisions related to indoor climate control.

Generally, the results of the thesis contribute to an expanded problem definition and to a better understanding of the gap between research and practice regarding energy efficient indoor climate control in historic buildings. It is shown how the specific social and material context is crucial for enabling or limiting a transition toward more sustainable ways of controlling the indoor climate. Furthermore it is discussed how uncertainty can be managed and communicated to support decisions, and suggestions are given for how decision processes regarding indoor climate control can be supported with improved standards to facilitate a more sustainable management. A conclusion for further research is that scientific knowledge alone will not be able to guide the transition to a sustainable, low carbon future; technical research has to be complemented with reflexive research approaches that explore the actual practices of heritage management.

This doctoral thesis is based on the following papers:

I. Leijonhufvud, Gustaf and Charlotta Bylund-Melin. 2009. "Preventive conservation climate in historic buildings – some gaps in the knowledge". This paper has been translated from Swedish and was originally published in the Scandinavian peer-reviewed journal *Meddelser om konservering* no 1 2009, s. 22-30 with the title "Bevarandeklimat i historiska byggnader-Några kunskapsluckor."

II. Leijonhufvud, Gustaf, Erik Kjellström, Tor Broström, Jonathan Ashley-Smith, and Dario Camuffo. 2013. "*Uncertainties in damage assessments of future indoor climates."* In Climate for collections: Standards and uncertainties. Edited by Jonathan Ashley-Smith, Andreas Burmester, and Melanie Eibl, 405–18. London: Archetype Publications.

III. Broström, Tor, and Gustaf Leijonhufvud. 2010. "*The indoor climate in Skokloster Castle*." In Historical buildings as museums: Systems for climate control and heritage preservation. Edited by Davide Del Curto, 84–93. Firenze: Nardini Editore.

IV. Leijonhufvud, Gustaf, and Annette Henning. 2014. "Rethinking indoor climate control in historic buildings: The importance of negotiated priorities and discursive hegemony at a Swedish museum." *Energy Research & Social Science* 4 (0): 117-23. doi: 10.1016/j.erss.2014.10.005.

V. Leijonhufvud, Gustaf. 2016. Making sense of climate risk information: the case of future indoor climate risks in Swedish churches. *Climate Risk Management*. Available online 4 June 2016 doi:10.1016/j.crm.2016.05.003.

VI. Leijonhufvud, Gustaf, and Tor Broström. *"Standardizing the indoor climate in Swedish churches: opportunities, challenges and ways forward."* Manuscript. A shorter version of the manuscript has been accepted for publication in the proceedings of the 2nd International Conference on Energy Efficiency and Comfort of Historic Buildings, Brussels 2016.

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