

Contents

1	Introduction	1
1.1	Motivation	1
1.2	Hypotheses	4
1.3	Literature Review	4
1.3.1	Model Uncertainty	5
1.3.2	Numerical Uncertainty	7
1.3.3	Model Input Uncertainty	7
1.4	Purpose of Research and Objectives	10
1.5	Structure of the Thesis	11
2	Statistical Fundamentals and Uncertainty Quantification for Simulation Input	13
2.1	Background and Objectives	13
2.1.1	Literature Review	13
2.1.2	Objectives	15
2.2	Methodology	15
2.2.1	Tools	15
2.2.2	Data Analysis	16
2.2.3	Sources of Information	27
2.2.4	Flowchart for the Proposed Methodology	30
3	Uncertainty Analysis	33
3.1	Background and Objectives	33
3.1.1	Literature Review	33
3.1.2	Objectives	36
3.2	Methodology	37
3.2.1	Sampling	37
3.2.2	Evaluation of the Model for each Element of the Sample . . .	44
3.2.3	Methods for Interpreting Results	45
3.2.4	Combined Building Performance Simulation and Cost-Benefit Analysis	48
3.2.5	Case Studies	50
3.3	Results and Discussion	61

3.3.1	Simple Mathematical Model	61
3.3.2	Building Performance Simulation Model	66
3.4	Summary	77
4	Sensitivity Analysis	81
4.1	Background and Objectives	81
4.1.1	Literature Review	81
4.1.2	Objectives	92
4.2	Methodology	92
4.2.1	Scatter Plot Method	94
4.2.2	Elementary Effects Method	95
4.2.3	Variance-Based Method	98
4.2.4	Monte Carlo Filtering	99
4.2.5	Overall Sensitivity Analysis Methodology	101
4.2.6	Case Study	101
4.3	Results and Discussion	108
4.3.1	Scatter Plot Method	108
4.3.2	Elementary Effects Method	111
4.3.3	Variance-Based Method	114
4.3.4	Monte Carlo Filtering	117
4.3.5	Predicted Savings and Implementation	119
4.4	Summary	123
5	Application to Residential Building Design	125
5.1	Case Study	125
5.1.1	Quantification of Building Performance Analysis Input Uncertainty	128
5.1.2	Quantification of Cost-Benefit Analysis Input Uncertainty	129
5.2	Results and Discussion	132
5.2.1	Building Performance Analysis	132
5.2.2	Combined Building Performance and Cost-Benefit Analysis	144
5.3	Summary	155
5.3.1	Building Performance Analysis	155
5.3.2	Combined Building Performance and Cost-Benefit Analysis	156
6	Conclusions	159
6.1	Summary of Most Important Results	159
6.2	Guidelines for Applying the Developed Methodology	162
6.3	Potential of the Results and Expected Impact	164
6.4	Outlook and Future Work	164

A Appendix	167
A.1 Probability Distributions	167
A.2 Data Analysis for Identifying Dependence	173
A.3 Cost Functions	174
A.4 Nomenclature	175
List of Figures	181
List of Tables	185
Bibliography	187