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Energy Saving Potential and Interior Temperatures of Glazed Spaces

Evaluation through Measurements and Simulations

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Location	Says	Should be
Abstract Top	… glazing systems are constructed of 5 to 6 frameless single glass panes …	… glazing systems are constructed of 4 to 6 frameless single glass panes …
Acknowledgements Page 1, Middle	… deserves special mention for his carefully designed and controlled master`s thesis. The monitoring results from his study …	… deserves special mention for his careful design and control during my master`s thesis. The monitoring results from this study …
Acknowledgements Page 2, Middle	… Mika Vuolle and Bengt Hellström at Equa simulation Finland Oy …	… Mika Vuolle at Equa simulation Finland Oy and Bengt Hellström at Equa simulation AB ...
Terminology Page 2, Bottom	… The temperature of an opaque or glazed surface measured by unshielded thermocouples ...	… The temperature of an opaque or glazed surface measured by shielded or unshielded thermocouples ...
List of original publications Middle	… Energy saving potentila of glazed space: Sensitivity analysis, Energy Build. 60 (2015) ...	… Energy saving potentila of glazed space: Sensitivity analysis, Energy Build. 99 (2015) ...
Page 21 Bottom	… drawbacks with this method.	… drawbacks with properties of older concrete element balconies.
Page 25 Bottom	… which would maximize the heating-energy savings for the building.	… which would help to optimize the heating-energy savings for the building.
Page 25 Bottom	… has been pointed out in many previous studies [20].	… has been pointed out in previous study [20].
Page 26 Top	… with a high thermal mass (Figure 5).	… with a high thermal mass (like Figure 5).
Page 27 Middle	… previous DSF solutions in Finland and Sweden do not seem to have been particularly well optimized.	… previous DSF solutions in Finland and Sweden do not seem to be particularly well optimized.
Page 28 Top	… and 3) passive air exhaust passively through two windows. The temperature set-point.can be adjusted …	… and 3) passive air exhaust to the outside through two windows. The temperature set-point can be adjusted …
Page 30 Bottom	**Window model:** The G-value (solar heat gain coefficient) …	Window model: The g-value (solar heat gain coefficient) …
Page 33 Bottom	Furthermore, to monitor the heat losses from the building`s envelope structures …	Furthermore, to evaluate the heat losses from the building`s envelope structures …
Page 38 Bottom	In the Malmo case study described in Article V, ...	In the Malmö case study described in Article V, ...
Page 43 Top	… there is not as yet any such formal and universally recognized process ...	… there is not yet any such formal and universally recognized process ...
Pages 46-48 Equations 6-11 (uncorrectly shown in the printed version of the thesis)	$MBE(\%) = \frac{\sum_{i=1}^{n}(X_{meas,i} - X_{model,i})}{\sum_{i=1}^{n}(X_{meas,i})}$ (6) $RMSE = \sum_{i=1}^{n}(X_{meas,i} - X_{model,i})^2$ $CV(RMSE)(\%) = \frac{MRSE}{X_{meas}} = \frac{\sqrt{\frac{\sum_{i=1}^{n}(X_{meas,i} - X_{model,i})^2}{n}}}{X_{meas}}$ (7) $R = \frac{n\sum_{i=1}^{n} X_{model,i} X_{meas,i} - \left(\sum_{i=1}^{n} X_{model,i}\right)\left(\sum_{i=1}^{n} X_{meas,i}\right)}{\sqrt{n\left(\sum_{i=1}^{n} X_{model,i}\right)^2 - \left(\sum_{i=1}^{n} X_{model,i}\right)^2}\sqrt{n\left(\sum_{i=1}^{n} X_{meas,i}\right)^2 - \left(\sum_{i=1}^{n} X_{meas,i}\right)^2}}$ (8)	

	$MPE(\%) = \frac{1}{n}\sum_{i=1}^{n}\frac{X_{meas,i} - X_{model,i}}{X_{meas,i}}$ (9) $MAPE(\%) = \frac{1}{n}\sum_{i=1}^{n}\left\lvert\frac{X_{meas,i} - X_{model,i}}{X_{meas,i}}\right\rvert$ (10) $SI(\%) = \frac{E_{max} - E_{min}}{E_{max}}$ (11)	
Page 49 Middle	… di□rential-algebraic equation (DAE) solver …	… differential-algebraic equation (DAE) solver …
Page 50 Bottom	... the new generation simulation tools presented in reference [131]. The goal of the Annex 60 project is to develop ...	... the new generation simulation tools are presented in reference [131]. The goal of the Annex 60 project have been set to develop ...
Page 52 Bottom	... by multiplying the shading effect with the window`s basic g-value. [138, 86] This is ...	... by multiplying the shading effect with the window`s basic g-value. [138, 86]. This is ...
Page 53 Top	From those models, the detailed window model provides better simulation performance in cases where there is detailed knowledge of the window parameters requiring access to an extensive window database [136].	From those two window models, the detailed window model provides better simulation performance in cases where there is detailed knowledge of the window parameters (require access to an extensive window database) [136].
Page 53 Middle	Once it has been reached inside the zone, the diffuse solar radiation ...	Once radiation has been reached inside the zone, the diffuse solar radiation ...
Page 54 Middle	… are used to calculate on-linear convective transfer.	… are used to calculate on linear convective transfer.
Page 54 Middle	... from the reflection of direct light (which is not reflected back out) by dividing it …	... from the reflection of direct solar radiation (which is not reflected back out) by dividing it …
Page 58 Top	... the CIBSE accreditation test for the building-energy simulation tools [164].	... the CIBSE accreditation test for the building energy simulation tools [164].
Page 58 Bottom	IDA ICE 4 performs well in the test series.	IDA ICE 4 performed well in the test series.
Page 60 Bottom	... and for the indoor balcony climate (warmer in the winter time).	... and for the balcony climate (warmer in the winter time).
Page 64 Top	Very little external sun protection was encountered during this study in Finland.	Very little amount of external sun protection was encountered during this study in Finland.
Page 66 Top	... symbolic equation structure; (most other building performance simulation tools use variable assignment).	... symbolic equation structure (most other building performance simulation tools use variable assignment).
Page 76 and 79 Middle	COMARK DILIGENCE N2003/N2013: Air temperatures: 4 pts	COMARK DILIGENCE N2003/N2013: Air temperatures: 2 pts
Page 76 and 79 Middle	COMARK DILIGENCE N2003/N2013: Relative humidities: 4 pts	COMARK DILIGENCE N2003/N2013: Relative humidities: 2 pts
Page 78 Top	… a balcony front view, the balcony glazing, the inhabitants routines and …	… a balcony front view, the balcony glazing use charasteristic and …
Page 80 Middle	There are 4 air inlets of 100 mm diameter in each of the east, west and south sides of the cavity (a total of 12 inlets) at the bottom of the cavities.	There are 4 air inlets of 100 mm diameter at the bottom of the east, west and south facades` cavities (a total of 12 inlets).
Page 82 Middle	<u>Heating period (winter case) - system 5702</u> … are above east (GT32:1, GT32:2)...	<u>Heating period (winter case) - system 5702</u> … are above east (GT31:1, GT31:2)...
Page 84 Top	The aluminum foil from some sensors was removed for the measurements (right).	The aluminum foil (sensor guard) from some sensors had fallen off during the measurement (right).
Page 87 Bottom	... calibrated using manual and graphical calibration methods as described above in section 2.3.2.	... calibrated using manual and graphical calibration methods (described in sections 2.3 and 2.5).
Page 88 Top	… and a reliability analysis of the simple method (Article IV). The sensitivity analysis and the reliability analysis of the simple method were themselves …	… and a reliability analysis of the simplified method (Article IV). The sensitivity analysis and the reliability analysis of the simplified method were themselves …
Page 88 Middle	… in a technical sense, the Malmo building has many similarities …	… in a technical sense, the Malmö building has many similarities …
Page 90 Bottom	… model verification and a case-specific evaluation of energy efficiency impacts by variation.	… model calibration and a case-specific evaluation of energy efficiency impacts by sensitivity analysis.

Page 91 Top	3.3.1.1 Validation study	3.3.1.1 Calibration study
Page 91 Bottom	... kitchen, indoor storage cupboard, toilet, and entrance hall (Figure 28).	... kitchen, walk in closet, toilet, and corridor (Figure 28).
Page 94 Middle	After the model had been successfully validated, a starting point for the calculations was made, named the ‘base case’ (Figure 31). It was produced by making slight changes to the validated model and …	After the model had been successfully calibrated, a starting point for the calculations was made, named the ‘base case’ (Figure 31). It was produced by making slight changes to the calibrated model and …
Page 97 Middle	… the horizontal double glazing is 2.6 W/m2°C (g=0.62) (Table 16). The red brick wall’s U-value is estimated to be U=1.35 W/m2°C and its solar absorptivity α=0.75	… the horizontal double glazing is 2.6 W/m2°C (g=0.73) (Table 16). The red brick wall’s U-value is estimated to be U=1.35 W/m2°C and its solar absorptivity 0.75
Page 103 Top	The simulation analyses were made with standardized living habits for the tenants, which was the only difference between the calibration and simulation analyses.	The simulation analyses were made with standardized building use (living habits for the tenants, etc), which was the only difference between the calibration and simulation analyses.
Page 110 Top	In the simulation model. The inclusion of the flats’ properties …	In the simulation model, the inclusion of the flats’ properties …
Page 112 Bottom	... winter season, with very low solar radiation levels and sunshine hours i.e. during the Finnish winter.	... winter season, with very low solar radiation levels and sunshine hours.
Page 114 Bottom	... level of the balconies rise like a trend between the coldest (balcony 22) and the warmest (1 balcony) balconies …	... level of the balconies rise like a trend between the coldest (balcony 22) and the warmest (balcony 1) balconies …
Page 116 Middle	... directly reveal which temperature is best used as an indicator of actual energy savings. For example, is it the balcony mean, maximum and minimum temperature? Or is it the difference between the balcony and the outside air maximum, minimum and mean temperatures?	... directly reveal which temperature is the most reliable as an indicator of actual energy savings. For example, is it the balcony mean, maximum or minimum temperature? Or is it the difference between the balcony and the outside air maximum, minimum or mean temperatures?
Page 118 Top	Table 20, below, shows a statistical analysis of the correlation between the measured temperatures and the kilowatt-hourly savings.	Table 20 shows a statistical analysis of the correlation between the measured temperatures and the kilowatt-hourly savings.
Page 118 Top	… the kilowatt-hour savings (R^2=0.00-0.58) is not as clear as the correlation between the balcony temperatures and the percentual savings (R^2=0.03-0.35).	… the kilowatt-hour savings (R^2=0.03-0.35) is not as clear as the correlation between the balcony temperatures and the percentual savings (R^2=0.00-0.58).
Page 120 Middle	... obtained from the the Jokioinen Meteorological Observatory.	... obtained from the Jokioinen Meteorological Observatory.
Page 120 Bottom	This building’s usage is difficult to monitor.	This kind of building’s usage is difficult to monitor.
Page 121 Top	There are basically three kind of errors in building simulations compared to the real thing; 1) modeling assumptions ...	There are basically three kind of errors in building simulations compared to the real situation; 1) modeling assumptions ...
Page 122 Middle	... and internal heat loads data, there wasonly a 1 % difference between the simulated and monitored energy consumptions ...	... and internal heat loads data, there was only a 1 % difference between the simulated and monitored energy consumptions ...
Page 124 Bottom	… the background information outlined in section 2 suggests that …	… the background information outlined in Section 2.3.4 suggests that …
Page 125 Middle	… those sensors which were shaded from sun ...	… those sensors which were shaded from the sun ...
Page 127 Top	… the doors and windows (sensors 116, 118, and 120, for example).	… the doors and windows (sensors 116, 118, and 112, for example).
Page 129 Bottom	… it was very hard to model the trees accurately in the IDA-ICE program, for example, do the shading effects of the mixed forest vary significantly …	… it was too complicated to model the trees accurately in the IDA-ICE program, because the shading effects of the mixed forest vary significantly …
Page 129 Bottom	Therefore, one option would be to validate the simulation model without the residents present.	Therefore, one option would be to calibrate the simulation model without the residents presence.
Page 131 Middle	… the number of changes that would need to be made to the ‘base case’ in simple calculations …	… the number of changes that would need to be made to the ‘base case’ in simplified calculations …
Page 131 Middle	or dark paint (the ‘base case’ itself represents typical renovation solutions used in practice) .	or dark paint (the ‘base case’ itself represents typical renovation solutions used in practice).

Page 132 Top	The general focus on the construction is on the Helsinki Metropolitan Area Bottom of Form	The general focus on the construction is on the Helsinki Metropolitan Area.
Page 132 Top	It also turned out to be the most reliable solution for simulation (all orientations analyzed). Bottom of Form	It also turned out to be the most reliable solution for simulation (all orientations analyzed).
Page 137 Bottom	... the building's conduction heat losses, In addition to this ...	... the building's conduction heat losses. In addition to this ...
Page 138 Middle	... three of the four sensors' guards (Figure 49.) were still in place ...	... three of the four sensors' guards (Figure 49) were still in place ...
Page 142 Bottom	… a time of thesis publication (under construction under during spring 2017) and …	… a time of thesis publication (under construction during spring 2017) and …
Page 151 Middle	For example, the integrated balcony (Balcony 9) shows the highest heat losses from the adjoining flat in January, but it is not the warmest balcony in this period because of the poor fit of the glazing	For example, the integrated balcony (Balcony 9) shows the highest heat losses (and balcony temperatures) from the adjoining flat in January, but it was not the warmest balcony in the whole monitoring period because of the poor fit of the glazing.
Page 156 Bottom	However, no single factor impairing a glazed balcony's energy efficiency. For example, good thermal insulation completely cancelled out the energy-saving potential of the glazed balconies.	However, no single factor fully impair a glazed balcony's energy saving effect. For example, good thermal insulation do not completely cancel out the energy-saving potential of the glazed balconies.
Page 157 Middle	Their corrugated sheet metal balusters were rattled by the wind, and the balconies were hot in summer, which occasionally caused significantly high indoor temperatures in the glazed balconies.	Their corrugated sheet metal balusters were rattled by the wind, and were hot in sunny summer days, which occasionally caused significantly high indoor temperatures in the glazed balconies.
Page 157 Bottom	… a glazed balcony was 3593.2 kWh, and for the unglazed one it was 4135.9 kWh..	… a glazed balcony was 3593.2 kWh, and for the unglazed one it was 4135.9 kWh.
Page 159 Top	… the sum of the window, door and wall, whose significances are 34 %, 25 % and 6 % respectively, making a total of 85 %.	… the sum of the window, door and wall, whose significances are 34 %, 25 % and 6 % respectively, making a total of 65 %.
Page 165 Top	AIR TEMTERATURE AND OUTFLOW	AIR TEMPERATURE AND OUTFLOW
Page 166 Middle	… airing the balcony through the glazing. Figure 60 gives an estimate of the total cooling effect of a glazed balcony …	... airing the balcony through the glazing (Figure 60). Figure 59 and 60 together gives an estimate of the total cooling effect of a glazed balcony ...
Page 167 Middle	For example, the energy-saving measures may make the cavity space too hot in the summer …	However, the energy-saving measures may make the cavity space too hot in the summer …
Page 172 Top	Interestingly, with the external blinds it is possible to achieve 20.3 °C (Case 54), 20.9 °C (Case 59) or 21.8 °C (Case 57). The mean cavity temperature had overheating levels of 94, 323 and 467 degree hours respectively, with a 23 °C overheating criterion (Figure 62).	Interestingly, with the external blinds it was possible to achieve 20.3 °C (Case 54), 20.9 °C (Case 59) and 21.8 °C (Case 57) mean temperature levels inside the cavity, causing overheating levels of 94, 323 and 467 degree hours respectively, with a 23 °C overheating criterion (Figure 62).
Page 172 Bottom	… and does not model the two- (or actually three-.) dimensional problem …	… and does not model the two- (or actually three-) dimensional problem …
Page 180 Middle	… and reduces the temperature in the adjacent room by 0.5-1.0 °C, …	… and allows a reduce of the temperature in the adjacent room by 0.5-1.0 °C, …
Page 181 Middle	In designing new constructions, the measurements should be more comprehensive, …	In designing new constructions, the judgements should be more comprehensive, …
Page 182 Top	the correlation with the external surface temperatures was ≥0.97 and with the internal surfaces it was and ≥0.91	the correlation with the external surface temperatures was ≥0.97 and with the internal surfaces it was ≥0.91
Page 183 Top	… is the sum of the window, door and wall's significances (34 % + 25 % + 6 % = 85 %).	… is the sum of the window, door and wall's significances (34 % + 25 % + 6 % = 65 %).
Page 183 Bottom	… in which case the importance of sun protection greater (variable 34).	… in which case the importance of sun protection increase (variable 34).
Page 183 Bottom	… variable 20 (Supply air intake solution) and variable 19 (Building type ventilation (air change rate)) …	… variable 20 (Supply air intake solution) and variable 19 (Building ventilation type (air change rate)) ...
Original paper I Information sheet	Energy and Buildings vol. 89, 132–142	Energy and Buildings vol. 89, 132–141