

Table 6: Comparison of Min and Max Operative and Air temperatures for 1960LW (1.2 met, 0.96 clo) with electrical radiators with air velocity= 0.1 m/sec

Category	PPD	PMV	1960 LW_1.2 met, 0.96 clo		1960 LW_1.2 met, 0.96 clo	
			Electric radiators , V= 0.1m/sec		Electric radiators , V= 0.1 m/sec	
			Min Top °C	Min Tair °C	Max Top °C	Max Tair °C
I	< 6	-0.2<PMV<+0.2	22	22.3	23	23.3
II	< 10	-0.5<PMV<+0.5	20.5	20.8	24.4	24.7
III	< 15	-0.7<PMV<+0.7	19.5	19.8	25.3	25.6

From the table 6, it can be seen that the maximum operative temperature can be 25 °C and minimum can be 19.6 °C approximately in 1960 light weight buildings having electric heating systems.

CONCLUSION

This study presented acceptable range of indoor air and operative temperatures of a detached house in a cold climate of Finland fulfilling thermal comfort categories recommended by SFS-EN 15251 standard. The amount of temperature decrease depends on activity and clothing levels of occupants, air velocity, building properties such as heat distribution system, thermal insulation, and thermal mass.

ACKNOWLEDGEMENTS

I would like to dedicate my acknowledgment of gratitude towards my instructor and professor who gave me an opportunity to work on SAGA project.

REFERENCES

- D. Kaneda, B. Jacobson, P. Rumsey, R. Engineers, Plug load reduction: the next big hurdle for net zero energy building design. ACEEE summer study on energy efficiency in buildings, Pacific Grove, CA (2010), pp. 120–130
- P. Hoes, J.L.M. Hensen, M.G.L.C. Loomans, B. de Vries, D. Bourgeois: User behavior in whole building simulation, Energy Build, 41 (2009), pp. 295–302
- ASHRAE, ASHRAE standard 55, thermal environmental conditions for human occupancy. American Society of Heating Refrigeration and Air conditioning Engineers; 2010
- Newsham GR. Clothing as a thermal comfort moderator and the effect on energy consumption. Energy Build 1997; 26:283- 91.
- Fanger PO. Thermal comfort. Copenhagen: Danish Technical Press; 1970. CEN. EN 15251- 2007. Criteria for the indoor environment including thermal, indoor air quality, light and noise. European Committee for Standardization; 2007.
- ISO. ISO 7730. Moderate thermal environment e determination of the PMV and PPD

- indices and specification of the conditions for thermal comfort. International Organization for Standardization; 2005.
- Hensen JLM, Lamberts R. Building performance simulation for design and operation. Taylor and Francis; 2011.
- De Carli M, Olesen BW, Zarrella A, Zecchin R. People's clothing behaviour according to external weather and indoor environment. *Build Environ* 2007; 42:3965-73.
- De Dear R, Brager G. Developing an adaptive model of thermal comfort and preference. Final report ASHRAE RP-884, 1997.
- Faraway JJ. Extending the linear model with R: generalized linear, mixed effects and nonparametric regression models. CRC Press; 2006.
- Morgan C, De Dear R. Weather, clothing and thermal adaptation to indoor climate. *Clim Res* 2003; 24:267- 84.
- ASHRAE, ASHRAE standard 55, thermal environmental conditions for human occupancy. American Society of Heating Refrigeration and Air conditioning Engineers; 2010
- International Organization for Standardization, ISO7730:2005, Ergonomics of the Thermal Environment-Analytical Determination and Interpretation of Thermal Comfort Using Calculation of PMV and PPD Indices and Local Thermal Comfort Criteria, 2005.
- Fanger P. Thermal comfort: analysis and applications in environmental Engineering. United States: McGraw-Hill Book Company; 1970.
- Roberto, Z.F., G.H.C. Oliveira and N. Mendes, 2008. Predictive controllers for thermal comfort optimization and energy savings. *Energy. Buildings.* 40: 1353-1365. DOI: 10.1016/j.enbuild.2007.12.007
- European Standardization Organization. 2007. SFS EN ISO 15251, indoor environmental input parameters for design and assessment of energy performance of buildings addressing indoor air quality, thermal environment, lighting and acoustics.
- Sahlin P. Modelling and simulation methods for modular continuous system in buildings, PhD Thesis, KTH, Stockholm, Sweden; 1996.
- Björnsell N, Bring A, Eriksson L, Grozman P, Lindgren M, Sahlin P, et al. IDA indoor climate and energy. In: Proceedings of the IBPSA building simulation '99 conference, Kyoto, Japan; 199
- Moinard S, Guyon G. editors. Empirical validation of EDF ETNA and GENEC test-cell models, Subtask A.3, A Report of IEA Task 22, Building Energy Analysis Tools; 1999.
- Travesi J, Maxwell G, Klaassen C, Holtz M. Empirical validation of Iowa energy resource station building energy analysis simulation models, IEA Task 22, Subtask A; 2001
- Targo Kalameesa, et al. Development of weighting factors for climate variables for selecting the energy reference year according to the EN ISO 15927-4 standard, *Energy and Buildings* 47 (2012) 53–60.