Heating, cooling, electrical demand and comfort control in buildings

Ali Bagheria , Véronique Feldheimb, Christos S. Ioakimidisa,
a ERA Chair 'Net-Zero Energy Efficiency on City Districts, NZED' Unit
b Thermal Engineering and Combustion Department, UMONS, Belgium
Research Institute for Energy, University of Mons, Mons, BELGIUM

Ali.BAGHERI@umons.ac.be, Veronique.FELDHEIM@umons.ac.be, Christos.IOAKEIMIDIS@umons.ac.be

1- Context of the study

This study is part of the RESIZED project. Designing new city districts and analyzing old ones from energy management point of view is a growing idea. In RESIZED project, this goal is divided into four different parts. Urban design, energy consumption, energy production and optimization. Simplified models are a strong tool for calculating energy consumption in buildings but their application in larger scale has not been investigated yet. Until now we have developed our method to make the building's simplified model and in the second part, developing a district simplified model is under study in the RESIZED project.

2- Objectives

- Simplified models are strong tools for quantifying heating load and cooling load in buildings.
- Thermal networks provide a systematic way to develop equations for simple and complex models.
- Parameter identification of RC networks, provides a reliable model for energy management in building sector.

3- Model Schemes

Figure 1. Schematic simulated building in TRNSYS

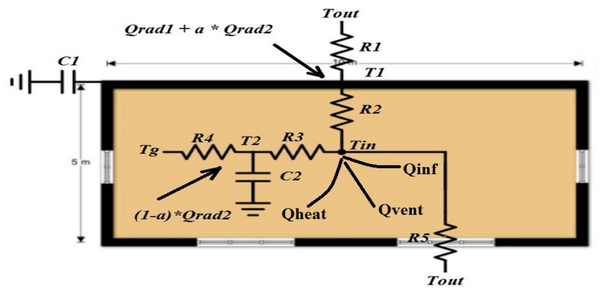

Figure 2. Making the thermal network out TRNSYS

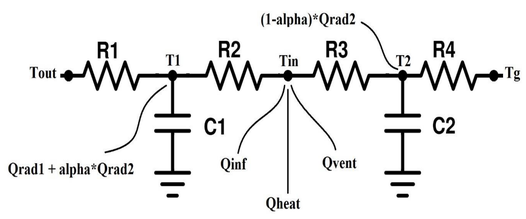

Figure 3. Final thermal RC network for making a building model

Table 1. Identified parameters for 4R2C model

	TRNSYS data	720 h data	
		Q	Fit = 85%
$R1$	0.0144	0.00013	>0 & <10
$R2$		0.0143	>0 & <10
$R3$	0.0067	0.001166	>0 & <10
$R4$		0.00427	>0 & <10
α	--	0.5	Fix
$C1$	24259200	4516	>1000
$C2$	10248000	4586	>1000

4- System identification

- Using 1 month data for identification.
- Data extracted from TRNSYS software.
- More than 80% of fitness.

$$C_1 \frac{dT_1}{dt} = \frac{T_{out}-T_1}{R_1} + \frac{T_{in}-T_1}{R_2} + Q_{rad1} + \alpha Q_{rad2}$$

$$C_2 \frac{dT_2}{dt} = \frac{T_{in}-T_2}{R_3} + \frac{T_g-T_2}{R_4} + (1-\alpha) Q_{rad2}$$

$$Q_{heat} + Q_{inf} + Q_{vent} + \frac{T_1-T_{in}}{R_2} + \frac{T_2-T_{in}}{R_3} = 0$$

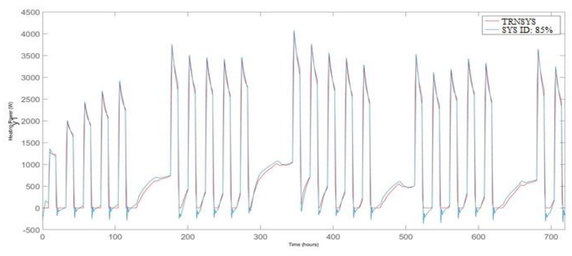

Figure 4a. 4R2C model identification using 720 h data

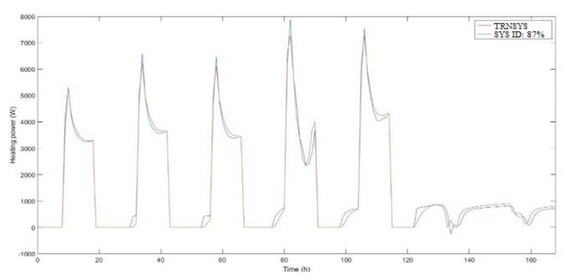

Figure 4b. 4R2C model identification using 168 h data

5- Results

- Using identified parameters to simulate one year performance.
- The model is able to simulate building heating load with high accuracy.
- Mean square error is very low.

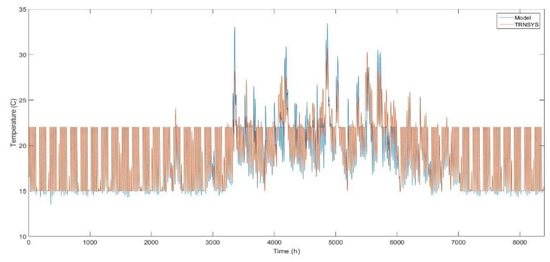

Figure 5. Simulated temperature for 1 year

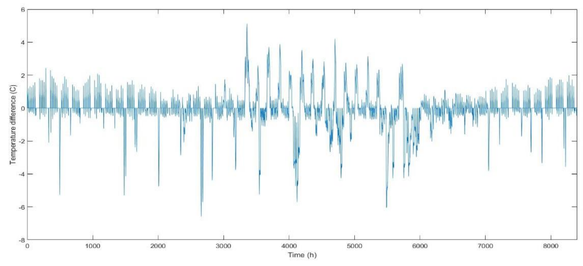

Figure 6. Hourly error for 1 year data

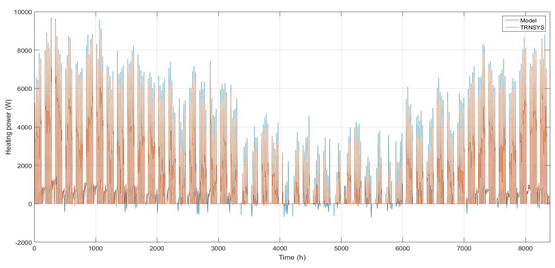

Figure 7. Simulated heating load for 1 year

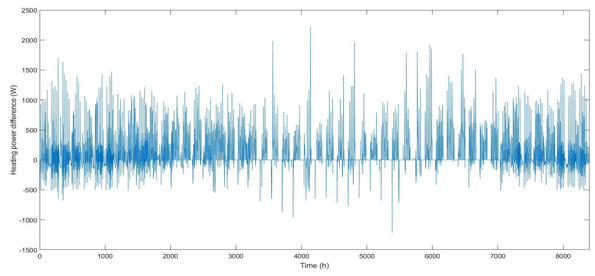

Figure 8. Hourly error for 1 year data

5- Conclusion

- The effectiveness of thermal networks to predict the heating load and indoor temperature in buildings is investigated.
- A "4R2C model" is used to simulate heating load and indoor temperature inside a building.
- The parameter identification has been done for 3 different sets of data (results from TRNSYS calculation).
- Data set (amount of information) can significantly impact on the accuracy of estimated parameters.
- The RC model trained with 1 month data can simulate heating load for one year accurately.

With support of the FP7 E.U. RE-SIZED (Research Excellence for Solutions and Implementation of NZED) Grant Agreement no 621408