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Research Excellence for Solution and Implementation of net Zero Energy city Districts

Thermal performance analysis of buildings by means of thermal networks

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1- Introduction

This work is a part of the RE-SIZED project which tries to create solutions related to net zero energy district problems. For this purpose, the research team is concentrating on urban planning, energy demand in buildings, storage and energy production, distribution, and control strategies. In this part we tried to use simplified thermal networks to study the indoor temperature and the heating load for a simple building.

2- Methodology

The developed simplified models are based on the thermal network approach.

- The stored energy in each part is represented by a thermal capacitance.
- Heat transfer between two parts occurs through a thermal resistance.
- By assuming constant capacitances and resistances all developed equations are linear.
- The models are able to simulate the indoor temperature and the heating load.

$$C_n \dot{T}_n = \sum_{n'=1}^{N} \frac{T_{n'} - T_n}{R_{n-n'}} + Q_n$$

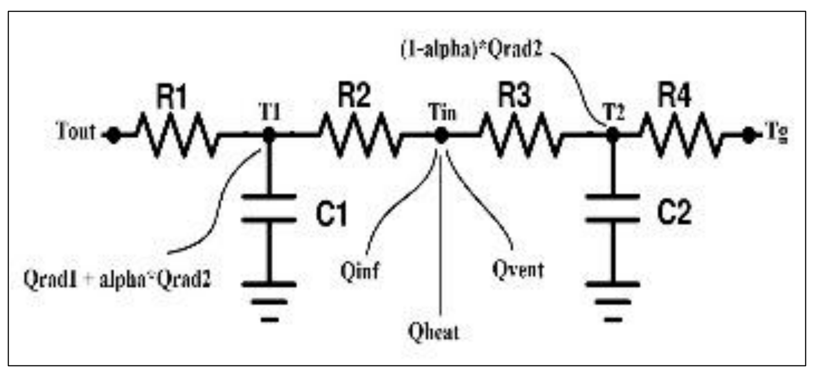

Fig 1 – 4R2C model

Fig 2 – Schematic of the simulated building in TRNSYS

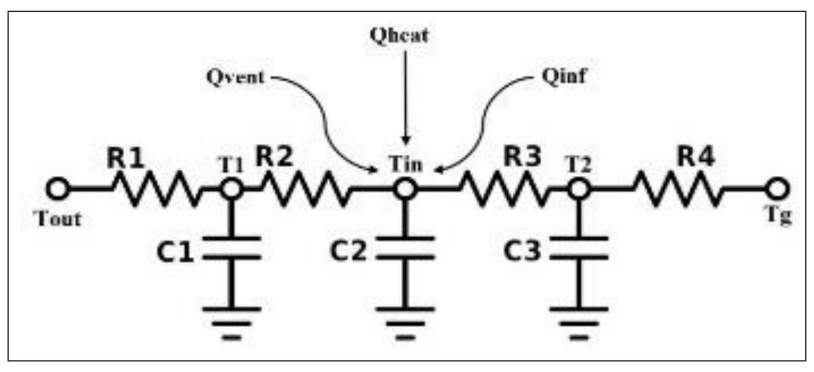

Fig 3 – 4R3C model

3- System identification results

System identification is the process to determine physical properties of unknown systems according to some experimental data or training data.

- Data is extracted from TRNSYS software for a simple office building.
- More than 80% of fitness is achieved for the heating load and the indoor temperature calculations.
- 4R2C model provides results for the heating load, while the 4R3C model output is the indoor temperature.
- Both models can simulate the thermal performance of the building accurately.

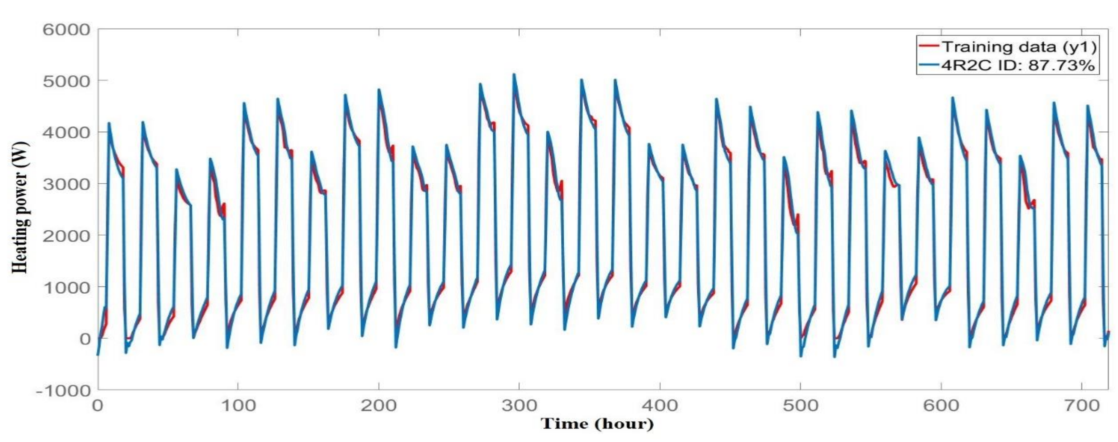

Fig 4 – 4R2C model identification for simulating the heating load

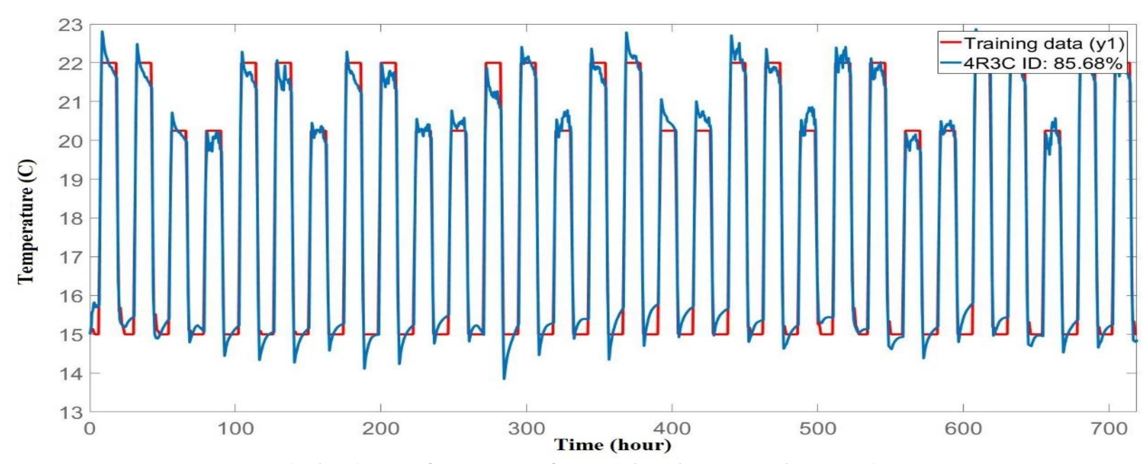

Fig 5 – 4R3C model identification for calculating the indoor temperature

Table 1 – identified parameters of 4R2C for 3 different data sets

	TRNSYS data	168h data	720h data	1500h data
		Fit = 73.28%	Fit = 87.73%	Fit = 87.64%
R1 (K/W)		0.0024	0.0001	0.0001
R2 (K/W)		0.0027	0.0199	0.0190
R1 + R2 (K/W)	0.01626	0.0051	0.0200	0.0191
R3 (K/W)		10.0000	0.0026	0.0027
R4 (K/W)		0.0092	0.0041	0.0043
R3 + R4 (K/W)	0.0108	10.01	0.0067	0.0060
C1 (Wh/K)	6738.67	15775.7	198167.8	310953.20
C2 (Wh/K)	2846.67	101.5	5061.438	4948.93

Table 2 – identified parameters of 4R3C for 3 different data sets

	TRNSYS data	168h data	720h data	1500h data
		Fit = 73.28%	Fit = 87.73%	Fit = 87.64%
R1 (K/W)	-	0.001	0.000	0.000
R2 (K/W)	-	0.003	0.019	0.019
R1 + R2 (K/W)	0.01626	0.004	0.019	0.019
R3 (K/W)	-	0.008	0.004	0.004
R4 (K/W)	-	0.008	0.003	0.003
R3 + R4 (K/W)	0.0108	0.016	0.007	0.007
C1 (Wh/K)	6738.67	577077.4	746.6	843.0
C2 (Wh/K)	-	212.2	220.2	220.6
C3 (Wh/K)	2846.67	993.4	19450.6	21058.4

4- Conclusion

- The capability of thermal network method to simulate the heating load and the indoor temperature in buildings is investigated.
- A "4R2C model" and a "4R3C model" are used to simulate the heating load and the indoor temperature.
- The parameter identification has been done for 3 different data sets(training data from TRNSYS calculation).
- Both 4R3C model and 4R2C model determine similar resistances for the system.

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